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ABSTRACT

This manual is designed by the Massachusetts Cooperative Extension Service as a guide for the control of the most common insects and related pests of vegetable crops grown commercially in Massachusetts. It contains general information on insects and specific descriptions of the major pests, their life cycles, and the damage they cause. The topics included describe: (1) Characteristics and development of insects; (2) Description and biology of major vegetable pests and damage they cause; (3) Pests of specific crops such as beans, cabbage, carrots, corn, lettuce, onions, peas, peppers, potatoes, spinach and tomatoes; (4) Toxicity of pesticides; and (5) The metric system and useful conversion factors for common measurement units. Application rates of active ingredients per acre for various concentrations of emulsifiables, wettables and dusts, and a list of pests in alphabetical order are presented at the end of this publication. (HM)

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DESCRIPTION AND BIOLOGY OF INSECTS AND RELATED PESTS INJURIOUS TO VEGETABLE CROPS

For Commercial Growers Only

SE 024 740

Prepared by the Cooperative Extension Service, Suburban Experiment Station, Waltham, Mass., College of Food and Natural Resources, University of Massachusetts, United States Department of Agriculture and Environmental Protection Agency, Massachusetts Counties Extension Services Cooperating.
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At the state level, the University of Massachusetts, a land-grant institution, conducts educational research in many fields. Extension faculty, working with county and regional Extension staff, act as catalysts in assisting individuals, families and communities utilizing available knowledge in making decisions important to them.

This publication is one of many reference documents prepared to serve individuals, families and communities in Massachusetts.

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DESCRIPTION AND BIOLOGY OF INSECTS AND RELATED PESTS INJURIOUS TO VEGETABLE CROPS

For Commercial Growers Only

Adrian G. Gentile*
with the cooperation of Donna T. Scanlon, Susan M. Richman**, and Margaret Bleichman****

PREFACE

This manual has been prepared as a guide for the control of the most common insects and related pests of vegetable crops grown commercially in Massachusetts. It contains general information on insects and specific descriptions of the major pests, their life cycles, and the damage they cause. Suggestions for the chemical control of the pests on specific crops are to be found in "Insect, Disease and Weed Control for Vegetable Crops in Massachusetts", which is revised and re-issued yearly by the Cooperative Extension Service.

Because the behavior of pests and growing conditions may vary with locations and specific crops, the information provided cannot be considered as applicable in all situations. Moreover, State and Federal regulations may suspend or modify the use of some of the suggested pest control methods. Additional information for specific situations should be secured from certified Extension Entomologists, Extension Specialists, State Chemical Leader or the State Regulatory Agency.

Under forthcoming new State and Federal regulations, a number of highly toxic pesticides will be classified as "restricted", for use only by certified applicators. Rules and regulations for safeguarding workers, consumers and the environment will be more strictly enforced. Since registration of pesticides for local use varies from State to State, the grower should always adhere to local use registrations and secure information from official regulatory personnel.

It is highly desirable that everyone concerned with insect pest control on commercial vegetable crops in Massachusetts secure information on identification of insect pests and their control only from qualified professional agricultural entomologists who are acquainted with Federal and State regulations on the use of pesticides and who are assigned official responsibility for pest control on vegetable crops.

Readers of this manual should familiarize themselves with the Northeast Pesticide Applicator Training Manual containing basic information on pesticides and their proper use in relation to man and the environment. Equipment calibration and other useful information are also found in the Northeast Manual.

The following sources of information were utilized in the preparation of this manual:

U.S.D.A. Bulletins and Experiment Station, Extension Bulletins and Manuals on agricultural pests and their control from the States of California, Florida, New Jersey, Pennsylvania, Ohio, Kentucky, Michigan, New York, Massachusetts, Iowa, Missouri, Illinois, Nebraska, West Virginia, Maine, Washington and Ontario (Canada).

Pocket Pesticide Calibration Guide. F. Boys and F. Murphey. Department of Entomology, University of Delaware.

Borror, D. G., D. M. DeLong and C. A. Triplehorn. 1976 (4th ed.) An Introduction to the Study of Insects. New York: Holt, Rinehart and Winston, 852 pp.; illus.

Davidson, R. H. and L. M. Peairs. 1966 (6th ed.) Insect Pests of Farm, Garden and Orchard. New York: J. Wiley and Sons, 675 pp.; illus.

Essig, E. O. 1926 Insects of Western North America. New York: Macmillan, 1035 pp.; illus.

Metcalf, C. L., R. L. Metcalf and W. P. Flint. 1951 (3rd ed.) Destructive and Useful Insects. Their Habits and Control. New York: McGraw-Hill, 1071 pp.; illus.

Common Names of Insects Approved by the Entomological Society of America. Entomol. Soc. Amer., College Park, Maryland, December 1970. 36 pp.

A Manual of Conversion Tables, Equivalents, and Dosage Calculations. H. T. Streu. College of Agriculture and Environmental Science, Rutgers—The State University of New Jersey.

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TABLE OF CONTENTS

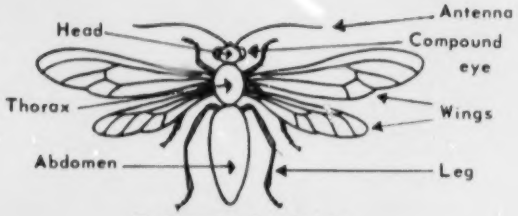
Preface ... 1
Pests Listed in Alphabetical Order ... 48
Characteristics of an Insect ... 3
The Development of Insects ... 4
Description and Biology of Major Vegetable Pests and Damage They Cause ... 5
General Feeders
- Aphids, ... 5
  - green peach ... 6
  - melon ... 6
  - potato ... 6
- Cutworms, ... 6
  - black or greasy ... 7
  - bronzed ... 7
  - dingy ... 8
  - spotted ... 8
  - variegated ... 8
- Earwigs ... 9
- Fruit flies or vinegar flies ... 9
- Garden springtail ... 9
- Japanese beetle ... 12
- Leaf miners ... 10
- Mites ... 11
- Six-spotted leafhopper ... 12
- Slugs ... 13
- Tarnished plant bug ... 13
- Whiteflies ... 15
- White grubs or June beetles ... 13
- Wireworms ... 16

Pests of Specific Crops ... 16
- Asparagus ... 16
  - Asparagus beetle ... 16
  - Asparagus miner ... 17
  - Cutworms ... 6
  - Japanese beetle ... 12
  - Wireworms ... 16
- Beans ... 17
  - Aphids ... 5
  - Bean weevil ... 17
  - Cutworms ... 6
  - Garden springtails ... 9
  - Leaf miners ... 10
  - Mexican bean beetle ... 17
  - Mites ... 11
  - Potato flea beetle ... 38
  - Seed corn maggot ... 31
  - Six-spotted leafhopper ... 12
  - Tarnished plant bug ... 13
  - Wireworms ... 16
- Cabbage, Cauliflower, Radish, Rutabaga, Turnip and Broccoli ... 18
  - Cabbage aphid ... 18
  - Cabbage looper ... 18
  - Cabbage maggot ... 19
  - Cutworms ... 6
  - Diamond-back moth ... 20
  - Imported cabbage worm ... 20
- Carrots, Parsley and Parsnip ... 21
  - Carrot rust fly ... 21
  - Carrot weevil ... 21
  - Onion thrips ... 36
  - Six-spotted leafhopper ... 12
  - Wireworms ... 16
- Corn (sweet) ... 22
  - Armyworm ... 22
    - common ... 22
    - fall ... 23
  - Billbug (illustration only) ... 24
  - Corn blotch leaf miner (illustration only) ... 11
  - Corn earworm ... 24
  - Corn flea beetle or brassy flea beetle ... 26
  - Corn leaf aphid ... 26
  - Cutworms ... 6
  - European corn borer ... 26
  - Japanese beetle ... 12
  - Mites ... 11
  - Northern corn rootworm ... 29
  - Sap beetles ... 30
  - Seed corn maggot ... 31
  - Southern corn rootworm (illustration only) ... 30
  - Stalk borer ... 32
  - White grubs ... 13
  - Wireworms ... 16
- Cucumber, Squash, Melon and Pumpkin ... 33
  - Aphids ... 5
  - Cutworms ... 6
  - Garden springtail ... 9
  - Leaf miners ... 10
  - Mites ... 11
  - Seed corn maggot ... 31
  - Six-spotted leafhopper ... 12
  - Squash bug ... 33
  - Squash vine borer ... 33
  - Striped cucumber beetle ... 34
  - Wireworms ... 16
- Lettuce ... 34
  - Cabbage looper ... 18
  - Cutworms ... 6
  - Green peach aphid ... 6
  - Lettuce root aphid ... 34
  - Six-spotted leafhopper ... 12
  - Slugs ... 13
  - Wireworms ... 16
- Onion ... 35
  - Onion maggot ... 35
  - Onion thrips ... 36
- Pea ... 37
  - Bean weevil ... 17
  - Cutworms ... 6
  - Pea aphid ... 37
  - Pea weevil ... 37
  - Seed corn maggot ... 31
  - Wireworms ... 16
- Pepper ... 37
  - Aphids ... 5
  - Colorado potato beetle ... 38
  - European corn borer ... 26
  - Green peach aphid ... 6
  - Pepper maggot ... 37
- Potato ... 38
  - Aphids ... 5
  - Cabbage looper ... 18
  - Colorado potato beetle ... 38
  - Corn earworm ... 24
  - Cutworms ... 6
  - European corn borer ... 26
  - Hornworms ... 40
  - Potato flea beetle ... 38
  - Potato leafhopper ... 39
  - Stalk borer ... 32
  - White grubs ... 13
  - Wireworms ... 16
- Spinach, Beet, Chard ... 40
  - Aphids ... 5
  - Cabbage looper ... 18
  - Leaf miners ... 10
  - Mites ... 11
  - Potato flea beetle ... 38
- Tomato, Eggplant ... 40
  - Aphids ... 5
  - Colorado potato beetle ... 38
  - Corn earworm ... 24
  - Fruitflies or vinegar flies ... 9
  - Green peach aphid ... 6
  - Hornworms ... 40
  - Leaf miners ... 10
  - Mites ... 11
  - Potato flea beetle and other species ... 38
  - Whiteflies ... 15

Toxicity of Pesticides ... 41
Categories of Toxicity ... 43
The Metric System ... 44
Useful Conversion Factors for Common Measurement Units ... 45
Application Rates of Active Ingredients Per Acre for Various Concentrations of Emulsifiables, Wettables, and Dusts ... 46
Equivalents Helpful for the Measurement of Small Quantities of Liquid Material ... 47

CHARACTERISTICS OF INSECTS

There are several external structural characteristics which distinguish insects from other arthropods (lower animals with articulated legs and other appendages). First, an insect has three distinct body divisions - the head, the thorax or middle section, and the abdomen. The head of the insect bears the eyes, antennae and mouth parts; the thorax bears the legs and wings; the abdomen is usually devoid of legs in the adults and bears the reproductive or copulatory appendages. As a rule, the adult insects have three pairs of legs, and if endowed with wings they may have one or two pairs. These characteristics readily distinguish insects from the adults of other types of arthropods such as mites and spiders which have four pairs of legs and no wings.

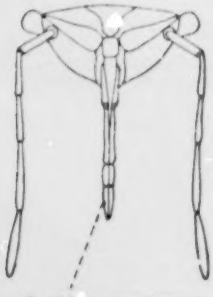


Body parts of an insect.

The following additional organs may be found on each of the above body divisions:

HEAD - Most adult insects have one pair of large compound eyes made up of hexagonal facets. In addition to the compound eyes, there are usually three *ocelli*, or simple eyes. These are located on the upper part of the head, between the pair of compound eyes. The antennae, or feelers are located near the compound eyes.

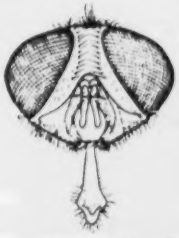
Insects of agricultural importance have mouthparts structured to satisfy their different feeding habits. The following are, in general terms, typical examples of mouthparts to be found in these insects. The chewing insects have mouthparts designed to bite and grind (beetles, caterpillars, etc.). These mouthparts include an upper and lower lip, a pair of jaw-like structures known as mandibles, operated by strong muscles, and a second pair of weaker jaw-like structures known as *maxillae*. Organs for smell and taste may be located on smaller appendages (*palpi*) attached to the *maxillae* and to the upper lip. Mandibles and *maxillae* have side to side movement for grasping, gouging and grinding the food. The sucking



Sucking mouthparts.

Siphoning mouthparts.

Chewing mouthparts.



Lapping-sponging mouthparts.

types of mouthparts may have a long and slender beak (aphids, stinkbugs, scale insects, etc.) or a coiling proboscis (moths and butterflies). The mandibles and *maxillae* of the former insects are modified into stylets housed in the elongated lower lips and capable of piercing plant tissue and withdrawing sap. For moths and butterflies feeding on flower nectar the *maxillae* are modified into a siphoning-sucking proboscis. In the house fly and related non-biting species the lower lip is modified into a sponging-lapping organ.

THORAX - This body division is subdivided into three sections. The first section, or *prothorax*, is just behind the head. The second section, or *mesothorax*, is next. In winged forms it bears the forewings. The last section, or *metathorax*, bears the hindwings, if present. If only one pair of wings is present, it will be attached to the *mesothorax*. Each of the three sections of the *thorax* bears one pair of jointed legs, for a total of six legs. The way in which insects' legs are constructed and joined may enable them to walk, jump or hop.

ABDOMEN - This is the third and last section of the body. It never bears wings nor true legs (the abdominal legs of caterpillars, sawfly larvae etc. are called prolegs, hence are not true legs). At the end of the abdomen in the adult female insect there is a structure called the ovipositor, which is the egg-laying apparatus. It is sometimes specialized so that it is capable of boring holes or sawing slits in the plant tissues (some species of thrips, tarnish plant bug, etc.) into which the eggs will be inserted.

Insects breathe through openings along the sides of their bodies known as spiracles. The spiracles open into a network of tubes called *tracheae* which are internal structures which have a function similar to that of lungs in higher animals.

The above description of the basic structural characteristics of insects should make it possible for the reader to distinguish an insect pest from other plant pests referred to in the text.

THE DEVELOPMENT OF INSECTS

Some insect pests of vegetables may give birth to live young (aphids, some scale insects, etc.). The majority, however, hatch from eggs. The stages through which insects go while developing from egg or young to adult are collectively known as *metamorphosis* (change of structure).

In some of the more primitive forms of insects, there is little change in external body structure from the young to adult except for a gradual increase in size. Springtails and firebrats are examples of insects without metamorphosis.

Most insects, however, go through one of three possible types of metamorphic development; gradual, incomplete or complete, characterized as follows:

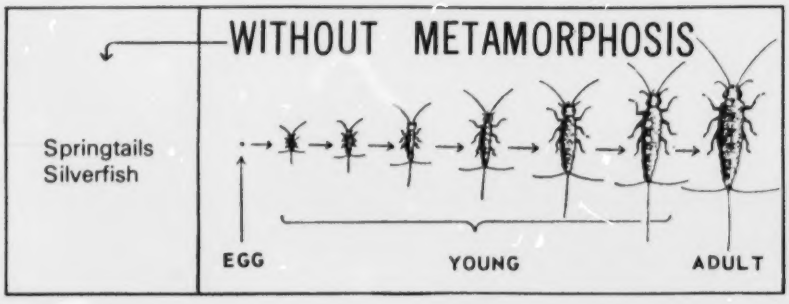
GRADUAL METAMORPHOSIS: After hatching from an egg or being born alive the young goes through only slight external body changes before reaching adulthood. The young insect, called a nymph, resembles the adult except for size and the lack of wings. Through a series of steps called instars the immature insect develops to full maturity. At the end of each instar the nymph molts its old shell. In winged species or forms, the last two nymphal instars present outside wing pads or wing stubs. The nymphs, as a rule, are found in the same habitat as the adults, feeding on the same host plants. Examples of insects with gradual metamorphosis are grasshoppers, leafhoppers, roaches, plant bugs, aphids, etc.

INCOMPLETE METAMORPHOSIS: This development is also gradual, but the young, called *naiads*, are strikingly different from the adult in appearance and habits. They are aquatic, with gill structures which are lost in the adults. The young and adult stages of some of these insects are of importance as predators of other insects. Examples of such insects are the dragonflies, damselflies, and mayflies.

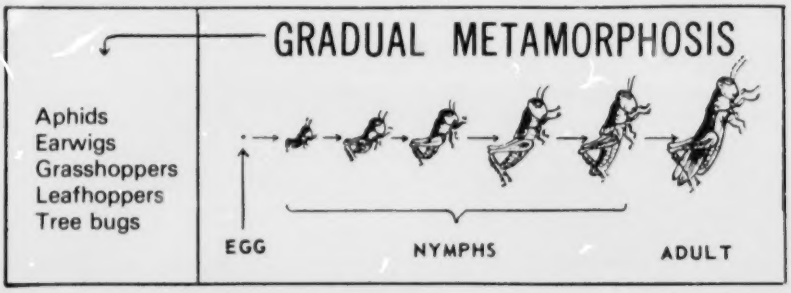
COMPLETE METAMORPHOSIS: Insects such as beetles, bees, ants, flies, butterflies and moths all go through a complete metamorphosis. In this type of development the changes which occur between the egg and adult stages are very marked. The young, called larvae, do not resemble the adults. Features such as mouthparts, legs, antennae, shape of body, as well as feeding habits, differ greatly in the larva. For example, a caterpillar is the larval stage of a moth or of a butterfly; a grub is the larva of a beetle; a maggot is the larva of a fly. Between the larval stage and the adult, these insects have an intermediate stage called "pupa". This may be naked or enclosed in a silken cocoon or in a hard case (puparium of flies). During the pupal stage the insect does not feed but undergoes drastic external and internal changes (inclusive of wing development) culminating with the emergence of a butterfly from what was once a caterpillar, a beetle from a grub, a fly from a maggot, etc.

As a general rule the young and the adult stages of insects with complete metamorphosis have different feeding habits and therefore may be found in different habitats or on different parts of the host plant. During egg laying the adult is found on the host plant on which the larva feeds. Major exceptions to this rule are offered by scale insects, white flies and thrips whose atypical metamorphoses present developmental stages with characteristics and habits reminiscent of the gradual and complete metamorphoses. Knowledge of the type of metamorphosis as well as of the appearance and habits of all the stages of development pertinent to a given plant pest is necessary for the proper selection and application of means of control.

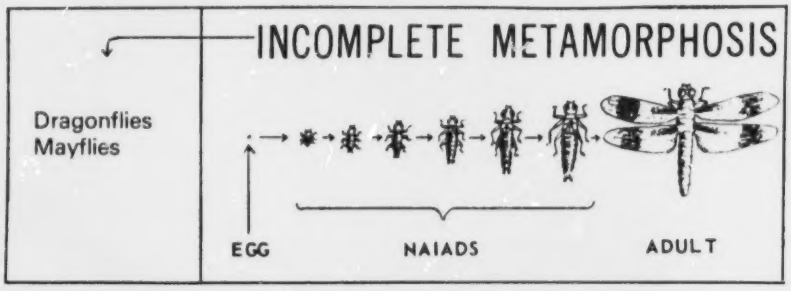
In GROUP 1 the insect that comes from the egg looks exactly like it will when grown, except that it will then be larger.



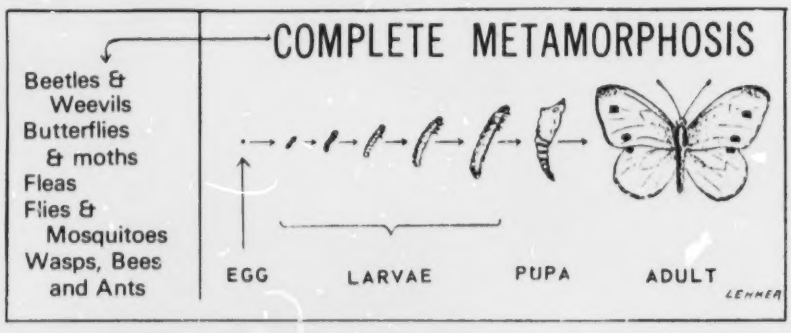
Insects in GROUP 2 change shape gradually. There are three stages of growth, each looking more like an adult.



The young insects in GROUP 3 change shape gradually. They do not look like adults until shedding their last skin. Then there is a quick change.



All insects in GROUP 4 go through four stages of growth. None of the young looks like the adult. There is a great change in shape when the adult emerges from the pupal stage.



DESCRIPTION AND BIOLOGY OF MAJOR VEGETABLE PESTS AND DAMAGE THEY CAUSE

GENERAL FEEDERS

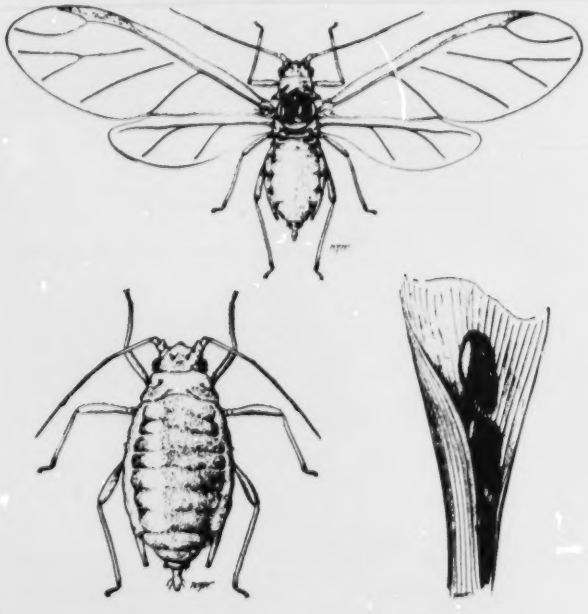
APHIDS

HOSTS: Nearly all vegetable crops may be infested and damaged by aphids. Some species are host-specific.

DAMAGE: Subtraction of plant sap; distortion and/or death of plant parts, including roots (see root aphids); secretion of unsightly waxy material and/or of sticky honeydew, the latter giving rise to black and unsightly sooty molds; transmission of viruses and other plant diseases.

DESCRIPTION: See individual species.

LIFE CYCLE: (For exceptions, see individual species). Most individuals of aphid populations found above ground level are wingless females. They give birth to living young without mating (parthenogenetic reproduction). Under crowded conditions and when food becomes depleted, some of the females develop wings and move to other host plants, where they will continue to give birth to living young parthenogenetically. In late fall, with the onset of low temperatures and death of host plants, the aphid populations give rise to male and female sexual forms which are usually winged. The function of the mated female is to lay the overwintering eggs in protected locations, usually on a perennial host plant, under bark, etc. The individuals hatching in the spring from these overwintering eggs give rise to populations of winged females that once more migrate to cultivated plants to reproduce parthenogenetically until the onset of cold weather. Some species which infest crops in greenhouses may reproduce all year round without mating. The parthenogenetic winged females of these populations migrate to outdoor plants in early spring.



Winged and wingless adult aphids and aphid eggs on a leaf.

Aphid species infesting roots may give rise to winged forms in late fall. These are sexual (male and female) forms which migrate to a perennial host plant (Lombardy poplar, etc.) where they lay the overwintering eggs which give rise in spring to gall-forming individuals. Female migrants move from the perennial host plant to the root system of vegetable crops and weeds in late spring and give rise to several generations of parthenogenetic wingless females until fall. (See life cycle of lettuce root aphid.)

Aphids produce several generations per year. A generation may be completed in two to four weeks. A parthenogenetic female may give birth to 150 or more living young. This explains the rapid build-up of infestations often observed under favorable greenhouse and field conditions.

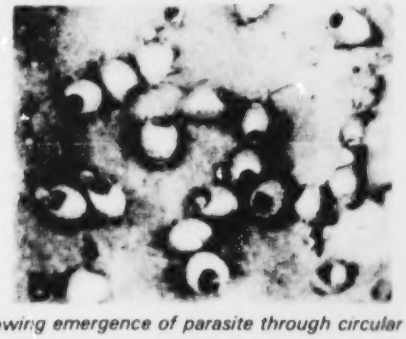
CONTROL: Preventative control of aphids is often advocated to prevent the transmission and spread of virus and related diseases. Unfortunately, many of these diseases may be transmitted to host plants by the simple probing of a single aphid which has migrated from infected weeds and/or crops. Crop varieties resistant to viruses and related diseases should be utilized whenever feasible.

Parasite depositing egg in the body of an aphid.

Chemical control may become necessary on high cash crops and whenever the insect constitutes an unwanted artifact on fresh or processed produce. Populations of aphids should however be tolerated up to locally accepted economic thresholds. This is desirable since it reduces the use of chemicals and favors the build-up of predators and parasites. Learn to recognize parasitized aphids. (See illustrations.)

Seasonal conditions may affect the build-up rate of aphids on commercial crops. Moreover, some species are more prevalent in early spring and fall (green peach aphid), while others are favored by high summer temperatures (corn leaf aphid).

Timing the plantings of given crops to avoid periods of major population explosions of given aphid species and cultivars resistant or tolerant to aphids should be utilized whenever feasible.



Aphids showing emergence of parasite through circular openings.

GREEN PEACH APHID, *Myzus persicae* (Sulzer), the most common species of aphids.

HOSTS: Broad host range: nearly all cultivated vegetables may be colonized by this pest, especially in spring and fall.

DAMAGE: Typical of aphids. This is the most injurious species of aphid. It transmits a large number of viruses and related diseases. It is one of the major vectors of cucumber, melon and squash mosaic viruses and of lettuce mosaic virus.

DESCRIPTION AND LIFE CYCLE: Pink wingless forms may occur in early spring and fall, but pale green to yellow forms are more prevalent. Winged forms have darker stripes on the adbomen. This aphid overwinters in the egg stage outdoors, but its parthenogenetic females may be common in greenhouses all year round. Several generations may occur outdoors in spring and fall.

CONTROL: Chemical control of this aphid may often become necessary especially during spring and fall. Pest management may be practiced on some crops, especially during the summer. Control of aphids on transplants while in greenhouse may delay buildup of field populations. The control of this aphid may delay but not prevent the occurrence and spread of cucumber, melon and squash mosaics and of lettuce mosaic among susceptible cucurbit and lettuce cultivars.

MELON APHID, *Aphis gossypii* Glover

HOSTS: Melons, squash and many other cucurbits, weeds, ornamentals, etc.

DAMAGE: Typical of aphids. Vector of virus and related diseases.

DESCRIPTION AND LIFE CYCLE: This aphid ranges from pale to very dark green, nearly black, with black leg joints, cornicles and eyes. Several generations develop per year. It overwinters in the egg stage on weeds, etc. and is most prevalent in the field in late spring and early summer. It is present also in greenhouses all winter long.

CONTROL: Chemical control may prove necessary in greenhouses and outdoors. Pest management practices may prove helpful outdoors, especially in summer and early fall. See green peach aphid for virus control information.

POTATO APHID, *Microsiphum euphorbiae* (Thomas)

HOSTS: Potato, tomato, eggplant, bean, pea and many other vegetables, forage crops, weeds, etc.

DAMAGE: Typical of aphids. Vector of viruses and related diseases.

DESCRIPTION AND LIFE CYCLE: Body coloration varies from light green to pink or from mottled green to pink. The green individuals often have a dark longitudinal stripe on the back. Sexual forms occur in the fall. The overwintering egg is laid mainly on stems of roses.

CONTROL: See green peach aphid.

CUTWORMS:

Several species may injure vegetable crops.

HOSTS: Many crops, grasses, weeds, etc.

DAMAGE: The larvae feed on seedlings at soil level or slightly below soil level (see illustration of black cutworm). The larvae of the climbing species may also

injure most of the plant parts above ground including fruits, cabbage heads, etc.

DESCRIPTION: (See also individual species): The adults of all cutworms, often seen fluttering around lights at night, are stocky moths or "millers", triangular in shape at rest, with mottled grey to brown forewings, and with a wing span of 1½" to 2". The larva is a thick bodied, dull colored caterpillar, nearly 2" long when mature. It is sluggish and contracts into a ball when disturbed (see illustration of black cutworm). The pupa is stocky and naked, usually found in a soil cell. The eggs are oval and striated.

LIFE CYCLE (See also individual species): Most species hibernate in the immature larval stage under trash, in soil, etc. (In northern areas, some species may hibernate in the pupal stage.) Feeding activity continues to larval maturity in early spring. Pupation takes place in the soil. The emerging night flying moths may lay from 200 to more than 1000 eggs, singly or in patches on grasses, stems, fence posts, etc. The larvae hatch in 5 to 10 days, and feed at night, hiding in the soil near the surface or under debris during the day. The larval stage may last from a few weeks to 5 months, according to species and environmental conditions. Some species may stop feeding in late July and go into a resting stage until the following spring. The number of generations may vary from 1 to 4 according to the species and environmental conditions.

CONTROL: Weed control is a very important practice for reducing the incidence of cutworms in cultivated fields. Fields previously in pasture or sod may require chemical or poison bait applications. Fall plowing of these fields may also help destroy many of the hibernating stages of the cutworms. Newly planted fields should be kept under strict surveillance to detect incipient outbreaks and prevent serious damage to seedlings.

SPECIES OF CUTWORMS TO BE FOUND IN THE NORTHEAST

(See also comparative illustrations)

THE BLACK OR GREASY CUTWORM, *Agrotis ipsilon* (Huefnagel)

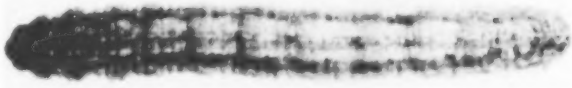
HOSTS: A serious pest of young corn, and seedlings of other crops.

DAMAGE: The larvae may cut off several seedlings at soil level as if only to satisfy its destructive instinct. Outbreaks frequently appear on flooded land. The night feeding larvae may cut pieces of foliage and carry them into their earthen burrows.

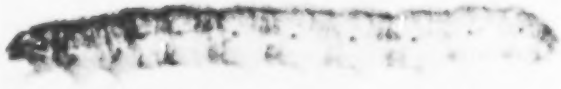
Black cutworm larva and typical damage to seedling.

DESCRIPTION: The moth has reddish to brownish grey forewings, with silvery patches at the bases and tips. The greasy, grey to brown larvae, are covered with convex granules of various sizes. They have a faint line down the middle of the back and on each side of the body.

BLACK CUTWORM Adult



Larva, dorsal view



Larva, lateral view

LIFE CYCLE: This pest overwinters as a pupa. The moth emerges in early spring, and may lay up to 1500 eggs, singly or a few together. The larvae are most abundant in late May and June. There may be more than one generation per year. A generation may be completed in 40 to 50 days.

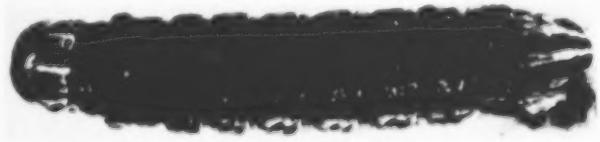
BRONZED CUTWORM, *Nephelodes emmedonia* (Cramer)

HOSTS: General feeder. May injure corn.

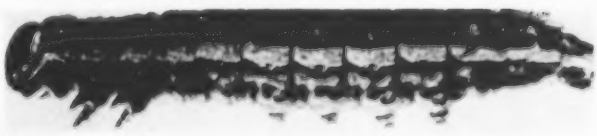
DAMAGE: Typical of cutworms.

DESCRIPTION: The dark bronzy brown larva is strikingly striped from head to tail with 5 clear cut pale bands. The adult appearance is typical of this group.

LIFE CYCLE: This cutworm overwinters as a partly grown larva. Other aspects of its life cycle are typical of cutworms. There is usually one generation per year.



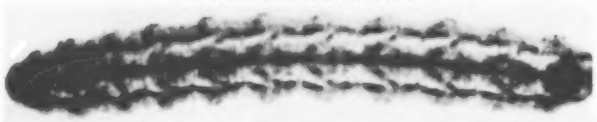
THE BRONZED CUTWORM



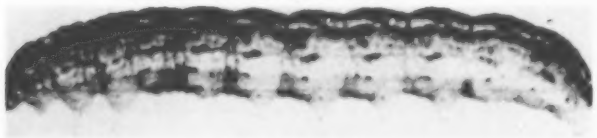
DINGY CUTWORM,
Feltia subgothica (Haworth)

HOSTS: Feeds generally on forage and vegetable crops.
DAMAGE: The larvae may feed on all plant parts.
DESCRIPTION: The dingy brown larvae have a buff grey dorsal stripe sub-divided into triangular areas on each segment, with a narrow marginal dark stripe on each side. The granulation on the skin is round and coarse. The moths or millers are mottled greyish brown.

DINGY CUTWORM Adult



Larva, dorsal view

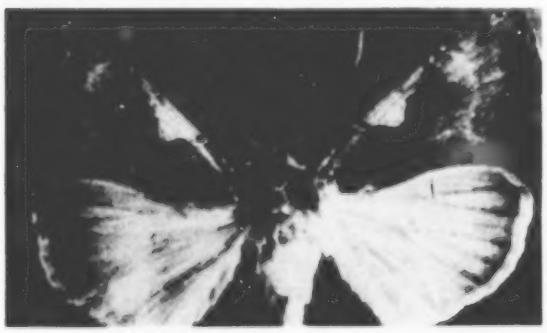


Larva, lateral view

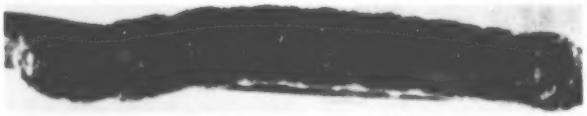
LIFE CYCLE: The insect overwinters as a partly grown larva. The larva may either become fully grown in early spring or, while still in the soil, may continue its inactivity until early summer, thus delaying pupation until August. The development from egg to adult may therefore take from 4 to 5 months. There is usually one generation per year.

SPOTTED CUTWORM,
Amathes c-nigrum (Linnaeus)

HOSTS: Feeds generally on many crops and weeds.
DAMAGE: Typical of climbing cutworms.



Adult



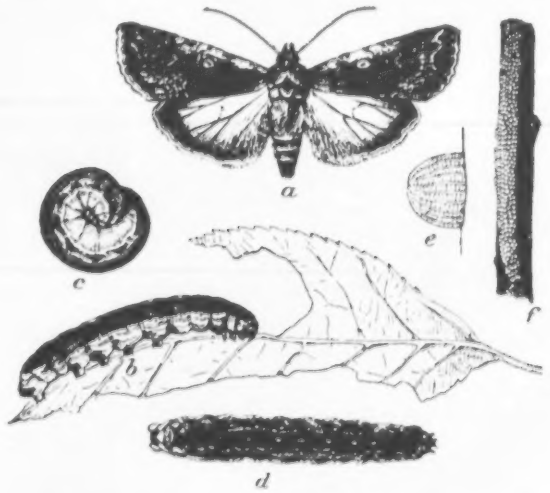
SPOTTED CUTWORM Larva, dorsal view

Larva, lateral view

DESCRIPTION: The smooth skinned larva is greyish brown to olive brown, with a pair of wedge shaped black dashes on the upper side of each body segment, becoming large and closer together toward the tail end. There is also a dark stripe on each side of the body. The adult has dull brown or grey forewings each with a yellow spot near the outer edge. Other characteristics are typical of the group.
LIFE CYCLE: This cutworm overwinters in the nearly mature larval stage. Eggs are laid singly or in patches of 100 or more, mostly on leaves. Other habits are typical of this group of insects. There may be 1 to 3 generations per season.

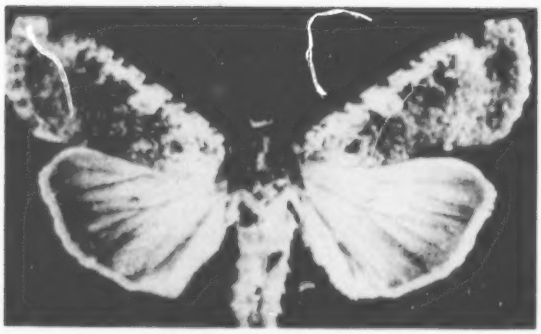
VARIEGATED CUTWORM,
Peridroma saucia (Huebner)

HOSTS: Feeds generally on many crops and weeds.
DAMAGE: Typical of the group; often severe due to its climbing and gregarious habits.
DESCRIPTION: The larva is smooth, greyish to mottled brown, with a length-wise series of pale yellow

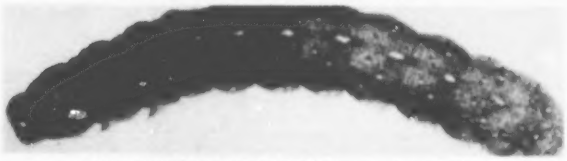


Variegated cutworm: a, moth; b, c, d, larvae; e, egg; f, egg mass.

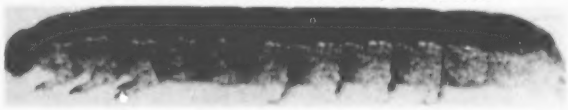
dots in the middle of the dorsal area. It has a dark "W" on the dorsal area of the eighth abdominal segment and orange and black stripes on each side of the body. The adult has brownish grey, reddish tinged forewings, with darker margins, wavy transverse lines, and kidney shaped spots. The hind wings are typically pale grey, with a brownish border.



VARIEGATED CUTWORM Adult



VARIEGATED CUTWORM Larva, dorsal view



VARIEGATED CUTWORM Larva, lateral view

LIFE CYCLE: This cutworm overwinters as a pupa in soil or under debris. Adult emergence and egg laying take place in early summer. The eggs are laid on plants or fence posts and similar objects in groups of 60 or more. There may be 3 or more generations per season.

EARWIG, *Forficula auricularia* Linnaeus

HOSTS: Vegetables, flowers, ripe fruits, etc.

DAMAGE: The earwig, although beneficial because of its predaceous nature and scavenger habits, may at times feed on green plant shoots, and its mere presence on edible plant parts is objectionable.

DESCRIPTION: This dark reddish brown insect is up to 4/5" long, with sharp pincers or forceps at the tip of the abdomen, protruding 1/4 the length of the body. Short wing covers contain the folded membranous second pair of wings. The nymphs are similar to the adults, but lack wings. The white oval eggs are laid in masses in the ground.

LIFE CYCLE: The earwig undergoes gradual metamorphosis. Females lay their eggs in the fall, guarding their nests through the early stages of nymphal development. The earwig is a nocturnal feeder and hides during the day in debris and dark crevices or between plant parts.

CONTROL: The control of this pest should be carried on only when it becomes a true nuisance. Poison baits may prove effective for suppressing small infestations.

FRUITFLIES OR VINEGAR FLIES, *Drosophila spp.*

HOSTS: Mainly fruits of a number of crop plants.

DAMAGE: These flies are attracted to injured, decaying, or fermenting produce. They are mainly the disseminators of agents of fermentation. They are also a great nuisance in packing houses and at roadside stands. The larvae and eggs constitute unwanted fouling agents and artifacts on fresh and processed commodities.

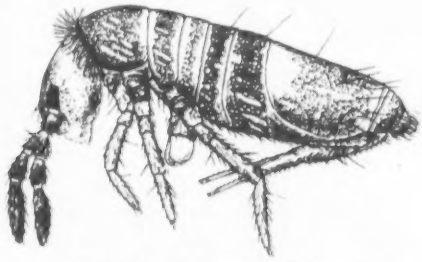
DESCRIPTION AND LIFE CYCLE: The adult fly is less than 1/8" long and brown to orange, with red eyes. The eggs are white and are suspended in the moist medium by two thread-like appendages. The larva is a typical maggot, creamy colored to transparent. The pupa has two horn-like breathing tubes. A female may lay up to 2000 eggs, mostly in moist media such as a crack in the skin of a tomato fruit, etc. The life cycle is completed in 7 to 10 days, allowing for large population build-ups.

CONTROL: Careful handling and prompt and proper storage of produce will discourage the build-up of the fly. Sanitation should aim at the prompt disposal of refuse from premises. Chemical treatment of harvested high cash produce while in the field and/or in storage may be necessary.

GARDEN SPRINGTAIL, *Bourletiella hortensis* (Fitch) and other species.

HOSTS: Seedlings of cucurbits, corn, beans, peas, spinach, etc.

DAMAGE: Springtail damage closely resembles that caused by flea beetles. Their feeding causes numerous and irregular holes in the tender true leaves of seedlings and pit-like depressions in the hypocotyls and cotyledons of newly emerging seedlings.



Springtail: adult greatly enlarged.

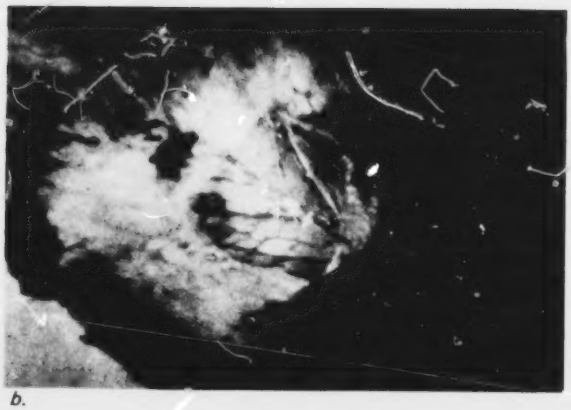
DESCRIPTION AND LIFE CYCLE: Springtails are extremely small (1/25" long) wingless insects. A forked and springing appendage, called the furcula, located on the ventral side of the body, enables these insects to leap forward (see illustration). Lacking true metamorphosis, young and adults look alike. The young are usually paler in color. The adults of the garden springtail are pale violet to slate blue. The eggs are transparent white and laid in groups. Young and adults surface to the soil level during cool and wet spring and early summer and cause severe damage to seedlings.

CONTROL: Chemical control may be necessary to protect seedlings during the early part of the growing season.

Springtails in soil

LEAF MINERS

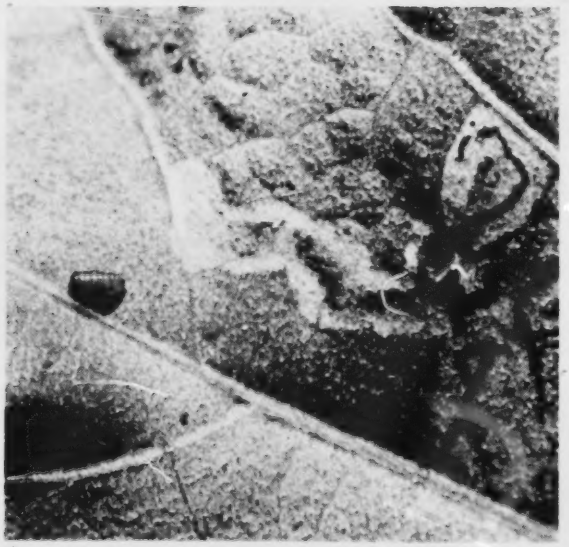
a.



b.

c.

e.



d.

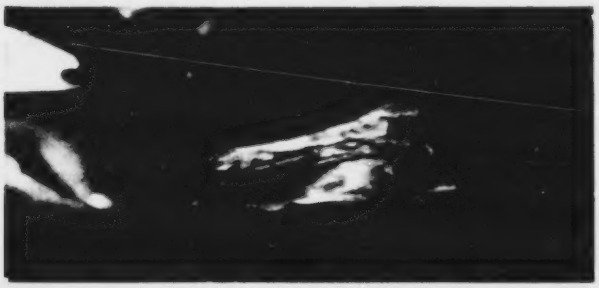
Leaf miners, damage and developmental stages: adult female leaf miner; b, blotch type mine with larva; c, egg punctures and young mines; d, pupa; e, serpentine type mine.

LEAF MINERS

A number of species are known as Serpentine and Blotch Leaf Miners according to their mining habits. The identification of species requires adequate expertise.

HOSTS: Cultivated plants such as corn, spinach, beets, beans, peas, etc., and weeds.

DAMAGE: The maggots eat the tissue between upper and lower surfaces of leaves. Their feeding causes large whitish blotches or blasted areas and, in the case of the serpentine leaf miners, slender winding mines. Severe infestations produce a scorch-like effect on the foliage of the host plant. Vegetable crops with edible leaves may be rendered unsaleable by less severe infestations as well as by the mere feeding of the adult and oviposition punctures which may appear in large numbers on plant foliage as stippled yellow dots (see illustration).



Corn blotch leaf miner damage to corn leaf.

DESCRIPTION: The adult is a fly with a hairy, slender body and, depending upon the species, from 1/16" to 1/6" long. The coloration may range from grey to black. It is usually seen crawling lazily on leaves or making short hopping flights from leaf to leaf. The oval egg is a translucent greenish white to white. The larva is a smooth maggot with mouth hooks. The pupal case (puparium) may vary in color from yellow to yellowish brown.

LIFE CYCLE: These insects may hibernate as pupae in soil or in plant debris. Adults are present in the fields in early spring. The eggs are inserted into the leaf tissue. The emerging larvae feed for 10 to 15 days and, depending upon the species, make serpentine mines or blotches. Pupation may occur either in the mine, in the soil, or under debris. Adults emerge 7 to 10 days later. The life cycle may be completed in 30 to 40 days. Two to three generations may occur during the growing season. The early summer infestations may be most injurious to corn and other vegetables.

CONTROL: Since a number of weeds are hosts of leaf miners, clean cultivation is helpful in reducing population build-up in cultivated fields. The presence of a large number of stippled-like punctures on non-edible crop leaves should not per se encourage the use of chemical control. Many of these punctures may be empty or contain parasitized eggs. A specialist with proper expertise will be able to determine, from the number of viable eggs and newly hatching larvae, whether chemical control measures are warranted.

MITES

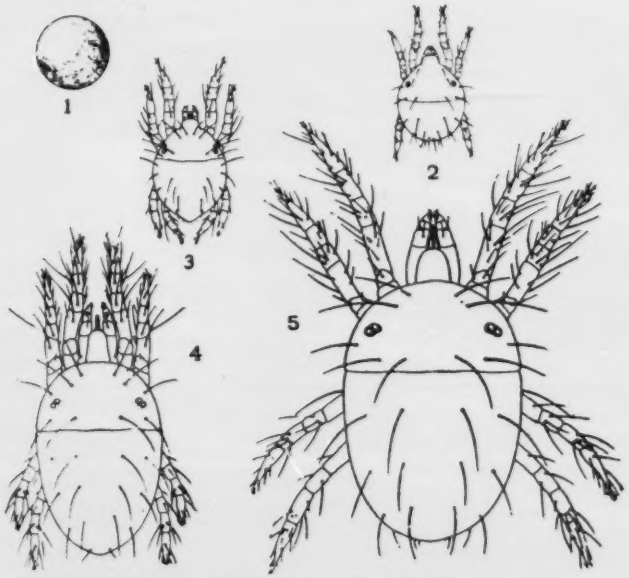
There are a number of species which require proper expertise for identification. (The uninitiated reader is reminded that mites are not insects.)

HOSTS: Numerous hosts among edible, ornamental plants, and weeds.

DAMAGE: In Massachusetts mite infestations usually start on transplants grown in greenhouses. Under favorable outdoor conditions these infestations may give rise to severe outbreaks. Mite feeding causes stippling, distortion and dropping of leaves. Webbing of infested plant parts is the most characteristic sign of heavy two-spotted spider mite infestation. Distortion of growing tips, cupping of leaves and blasting of leaf buds and/or flower buds may result from cyclamen mite and broad mite infestations.

Plant injury and webbing caused by spider mites.

DESCRIPTION: The greenish to orange adults of typical spider mites are about 1/50" long and oval, and have 4 pairs of legs. The male is smaller than the female. The amber to reddish eggs are globe-shaped. The broad mite and cyclamen mite are not visible to the naked eye and proper expertise should be sought for their detection and identification.



Spider mite: 1, egg; 2, larva; 3, protonymph; 4, deutonymph; 5, adult [after Ewing].

LIFE CYCLE: In the typical spider mite group, the eggs are laid singly. A female may lay up to 100 eggs during her 3 to 4 week life span. The egg is followed by a larval and

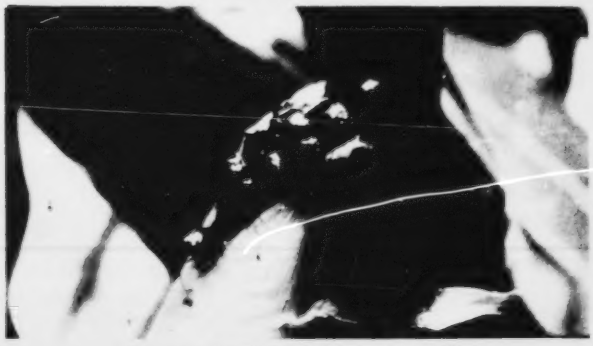
two nymphal stages. The life cycle may be completed in less than 2 weeks under optimum conditions. (See illustrations of developmental stages of spider mites.)

CONTROL: Mites are not common outdoor pests in the Northeast. Unseasonally warm and dry weather may favor their build up. Field infestations usually derive from translplants grown in greenhouses. Mite control measures should be applied to transplants prior to their transfer to the field, and especially during unseasonally warm and dry periods.

JAPANESE BEETLE,
Popillia japonica Newman

HOSTS: More than 200 species of plants including many weeds and ornamentals. Among edible crops: corn, asparagus, strawberries, grapes, and other berries, and numerous fruit trees.

DAMAGE: Larvae feed on roots; beetles feed on foliage and fruits. Root systems of many vegetable crops may be



Japanese beetles feeding on corn silk.

injured by the larvae especially when planted in soil previously in sod. Larvae may cause severe damage to roots of strawberries and asparagus. Beetles may feed heavily on corn silk and interfere with proper pollination, and on fruits and other edible plant parts reducing their marketability.

DESCRIPTION: The adult beetle is less than ½" long, shiny metallic green with coppery brown wing covers. The larva is a white "C" shaped grub, from 1/16" long upon hatching to 1" long when fully grown. Only an experienced observer is able to distinguish the grub of the Japanese beetle from other similar grubs. The egg is elliptical, 1/16" in diameter, creamy in color, with a finely pitted surface.

LIFE CYCLE: The beetle overwinters in the soil as a mature larva. Pupation begins in earthen cells in late May or early June. The adults begin to emerge in late June and may continue to emerge until September. An adult may live up to 30 days. The eggs are laid 1" below the soil surface and hatch about two weeks later. The average number of eggs per female is 30-35. The larvae feed until cold weather sets in. There is only one generation per year.

CONTROL: The adult beetle is a strong flier and its presence on cultivated plants may be the result of migration from distantly located breeding sites such as sod land, woods and other undisturbed areas. Therefore, before applying larvicides to the cultivated area, the presence of larvae should be established (see wireworms). Since the larvae of this insect may be confused with white grubs (larvae of the June beetles), proper identification is necessary before control measures are applied.

SIX-SPOTTED OR ASTER LEAFHOPPER,
Macrosteles fascifrons (Stahl)

HOSTS: Lettuce, carrot, parsley, celery, and other vegetables, as well as many weeds and ornamentals which may be also reservoirs of aster yellows, mycoplasm-like organisms.

DAMAGE: This leafhopper is a major vector of aster yellows. The infested and infected plants usually show a general yellowing of foliage and a clearing of veins. Plants are stunted and produce extra shoots, usually distorted. Lettuce plants develop a condition known as rabbit ear. Roots of infested carrots are smaller than normal and have hairy rootlets.

Seasonal life cycle of the Japanese beetle.

DESCRIPTION: The small, 1/8" long slender adult is greenish-yellow, with several black spots on the front end. It is very active and has the ability to jump quickly when disturbed. The nymph is greyish. (See illustrations of the life stages of the potato leafhopper).

LIFE CYCLE: This leafhopper overwinters in the egg stage on perennial weeds, winter grains, etc. In early spring the first generation is completed mainly on weeds. In early summer, the adults migrate to crop plants and become vectors of the aster yellows. At normal summer temperatures, the life cycle is completed in about 40 days. There may be several generations per year. (For additional information on the biology of leafhoppers see section on the potato leafhopper).

CONTROL: This leafhopper must feed on plants infected with aster yellows in order to transmit the organism to other plants. Therefore, whenever feasible, diseased plants should be destroyed immediately; however, neither this step nor chemical control will prevent entirely the transmission of the organism to crop plants in endemic areas. Cultivars resistant to aster yellows should be grown whenever feasible.

SLUGS

These pests are molluscs.

HOSTS: Wide range of crops.

DAMAGE: Slugs feed on all aerial plant parts, leaving large ragged holes in the foliage and shallow to deep holes in fruits, etc. A slimy trail is a sign of slug infestation.

DESCRIPTION: A slug is actually a snail without a shell. Slugs may be 1/4" to several inches long, mostly grey, and, in some species, dark spotted. They leave a trail of mucus on the surfaces on which they crawl.

LIFE CYCLE: Eggs are laid in a gelatin-like substance in protected areas. Up to 100 eggs may be laid, but batches of 20-30 are more common. The young resemble the adult. Most slug species may overwinter as eggs or adults. The eggs hatch in the spring. Slugs reach adulthood in 3 months to a year, depending upon the species and the environmental conditions. Overwintering eggs which hatch in the spring provide the nucleus of the new population every year. Slugs have both male and female organs on the same body and may act as males and females at the same or at different times of their adult lives. Self-fertilization is also possible. Shaded areas and, above all, moist and warm conditions are of paramount importance for the survival and reproduction of slugs.

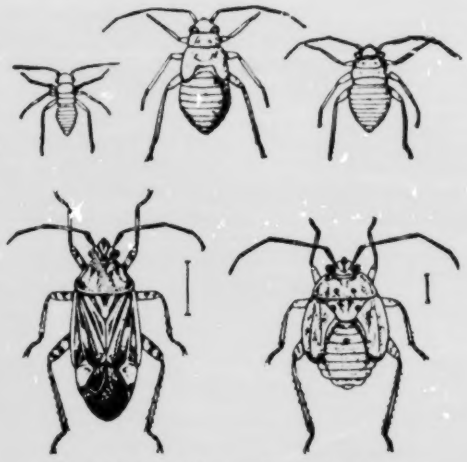
CONTROL: Removal of trash and crop residues from fields and adjacent areas may reduce the field incidence of slugs. The protection of high cash crops may require the broadcast of poison baits or other recommended molluscicides. Slugs may be transferred from greenhouses to fields by means of infested transplants and equipment.

TARNISHED PLANT BUG, *Lygus lineolaris* (Palisot de Beauvois)

HOSTS: Wide range of cultivated and ornamental plants, as well as numerous weeds.

DAMAGE: The adults and nymphs feed on plant sap with their sucking mouth parts. As they feed, they inject poisonous saliva, which causes injury to the plant tissues. Leaves may become deformed, stems and leaf petioles scarred and discolored. The buds and developing fruit may be either killed (blind buds), dwarfed, or deformed. On celery, the insect often causes "black joint", thus reducing the market value of the produce.

DESCRIPTION: The bronzish adult is about ½" long and marked with yellow and black dashes. The body is oblong, tapering toward the hind end. The head is small and triangular in shape, with prominent eyes. The young nymph, often misidentified as an aphid, is 1/25" long,



Tarnished plant bug: adult and nymphs.

oval, and yellowish green, with four round black dots on the thorax. As it matures, it develops wing stubs, which become fully developed wings in the adult (see illustration).

LIFE CYCLE: The adults pass the winter under rubbish, weeds, fallen leaves, etc. They lay eggs on weeds, vegetables, flowers, etc. The eggs are either inserted full length into stems, petioles, midribs of leaves and buds, or are laid among the petals or florets of flower heads. Egg hatching occurs 7 to 10 days later. The nymphs feed actively and undergo 5 molts prior to adulthood. The complete life cycle may be completed in 3 to 4 weeks. Three to four generations may occur in one year. Active populations may be found up to early September.

CONTROL: This is a very shy insect and its ability to hide makes it hard to detect in the field. Sweeping with an insect beating net will usually reveal its presence. Preferably, an economic threshold of infestation should be established locally for each crop before selecting a control measure. On crops not amenable to sweeping, the incidence of the bug must be assessed by personnel with adequate expertise.

WHITE GRUBS OR JUNE BEETLES, *Phyllophaga spp.*

HOSTS AND DAMAGE: The adults feed on the foliage of both deciduous and coniferous trees. The grubs or larvae are root feeders. They injure the roots of alfalfa, root crops, corn and other field and vegetable crops. This is followed by stunting, wilting, and death of seedlings as well as of the older plants.

DESCRIPTION: The robust adult beetles range from ½" to 1" in length and vary in color from light to dark

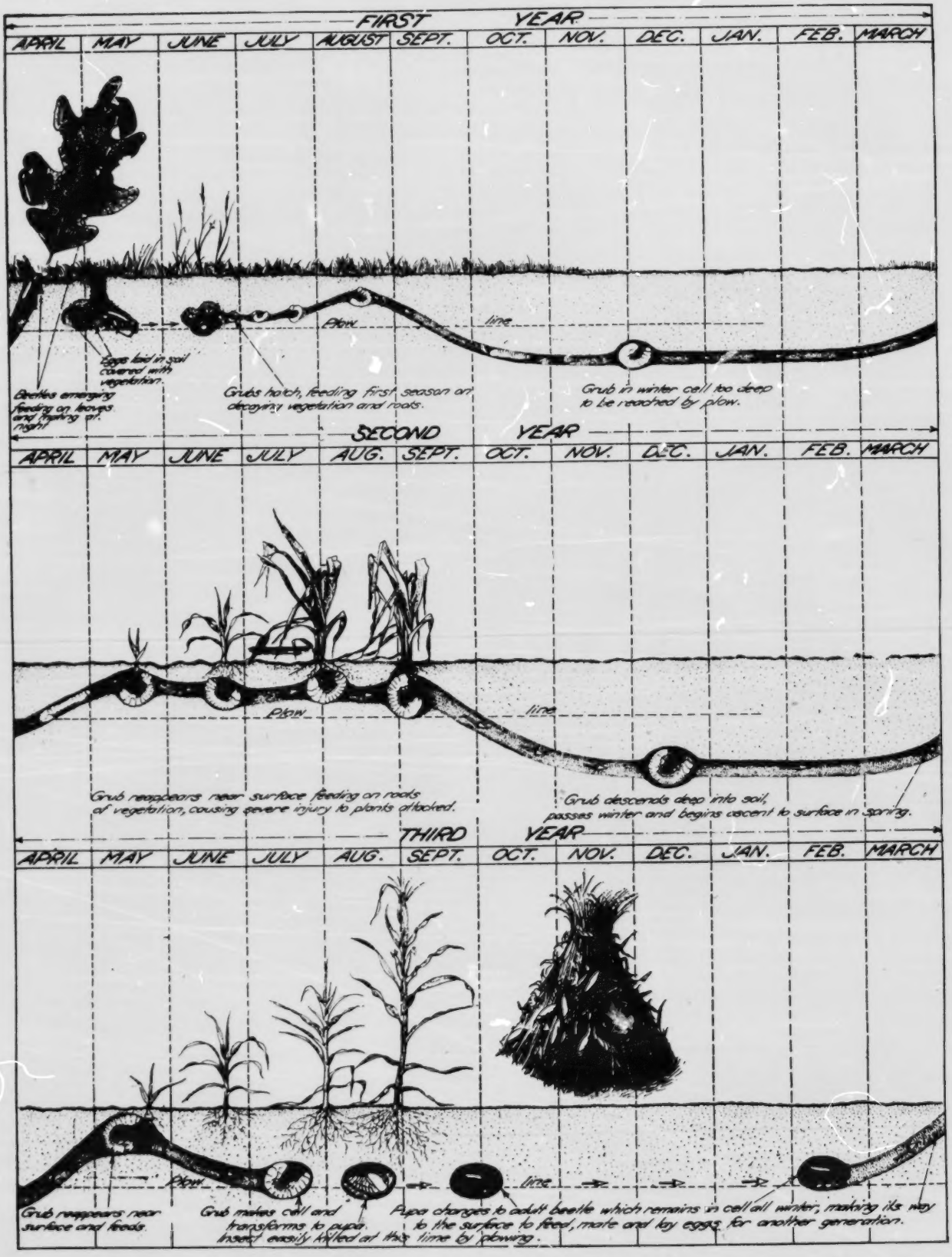
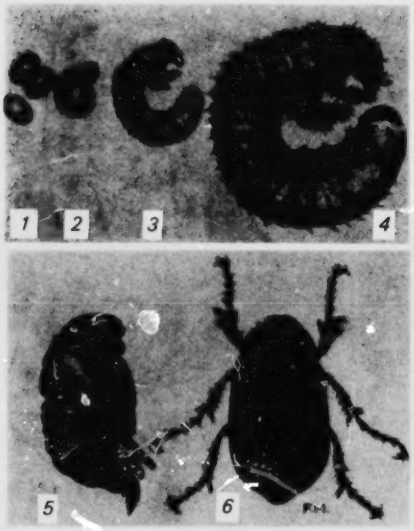

FIRST YEAR
APRIL MAY JUNE JULY AUGUST SEPT. OCT. NOV. DEC. JAN. FEB. MARCH
Plow line
Beetles emerging feeding on leaves and mating at night
Eggs laid in soil covered with vegetation
Grubs hatch, feeding first season on decaying vegetation and roots.
Grub in winter cell too deep to be reached by plow.
SECOND YEAR
APRIL MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MARCH
Plow line
Grub reappears near surface feeding on roots of vegetation, causing severe injury to plants attacked.
Grub descends deep into soil, passes winter and begins ascent to surface in spring.
THIRD YEAR
APRIL MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MARCH
Plow line
Grub reappears near surface and feeds.
Grub makes cell and transforms to pupa. Insect easily killed at this time by plowing.
Pupa changes to adult beetle which remains in cell all winter, making its way to the surface to feed, mate and lay eggs for another generation.

Diagram illustrating complete life cycle of white grubs, (June beetles), showing periods during which they can be killed by plowing.



Life-stages of a June beetle (from left to right): 1, egg; 2, 1st stage grub; 3, 2nd stage grub; 4, 3rd stage grub; 5, pupa; 6, adult beetle.

brown (see illustration). These are the well known June beetles. The larva is a typical grub (see illustration). Only an expert can distinguish it from other beetles larvae similar in appearance. The egg is pearly white. (See illustration of pupa)

LIFE CYCLE: Some of the more injurious and abundant species of white grubs have a 3 year life cycle (see diagram). Both adults and grubs overwinter in the soil. The adults feed at night, mostly on foliage of trees, and hide in the soil during the day. They mate in the early spring and lay eggs in the soil under a cover of vegetation. The young grubs feed on decaying vegetation and roots for the first season. Towards late fall, the grubs migrate below the plow sole to overwinter. The following spring, they migrate upward to feed on the roots of vegetation. In late fall, the grubs descend deeper into the soil to overwinter. In mid-summer of the third year, each grub makes a pupation cell in the soil and changes into a pupa. In the fall of the third year, the pupa transforms into the adult beetle, which will remain below the soil surface until the following spring. The overlapping of generations usually does not permit an accurate prediction of mass emergence of adult beetles.

CONTROL: Serious damage caused by grubs to cultivated crops may occur on land previously in sod, woods, etc. Plowing in early fall, before the grubs descend below the plow sole, and the elimination of weeds may help reduce grub populations. Plowing and disking in late spring may also help reduce grubs that have migrated above the plow sole. Control by means of granular formulations of pesticides, as in furrow or broadcast applications, may prove necessary for the protection of high cash crops. (See wireworms for additional suggestions on chemical control).

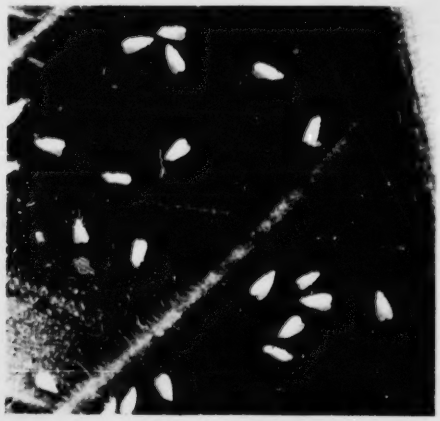
WHITEFLY,
Trialeurodes vaporariorum (Westwood)

This pest is a close relative of the scale insects.

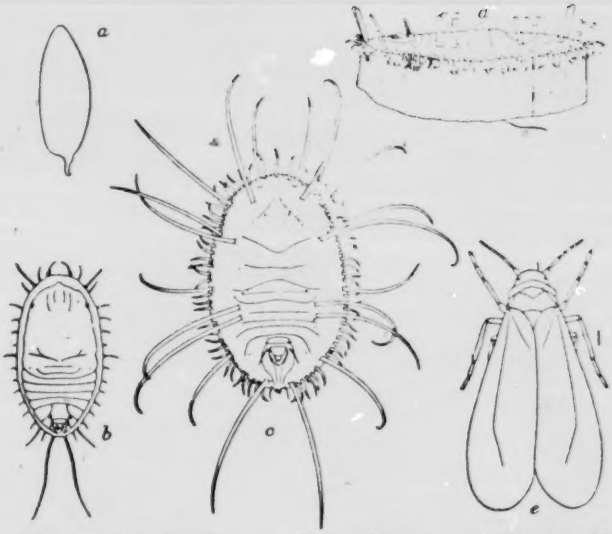
HOSTS: Prefers tomatoes, eggplant, peppers, and related plants, as well as many broad leaf weeds.

DAMAGE: The adults and nymphs feed mostly on the lower surface of the foliage of host plants. They suck juices from the plants and secrete large quantities of sticky and glistening honeydew, which gives rise to the development of an unsightly black sooty mold. Severe infestations may also cause defoliation of host plants.

DESCRIPTION: The adult male and female are tiny four-winged insects, snow white and approximately 1/16" long. The mature egg is black, elliptical and attached to the underside of the leaf by a short stalk. The newly hatched nymphs or crawlers are oval, flat, and greenish



Whitefly adults.



Life stages of whitefly: a, egg; b, crawler; c, nymph; d, pupa, side view; e, adult.

yellow. The crawler is the only nymphal stage capable of moving. The nymphs once settled do not move. They are scale-like and a transparent greenish-yellow. Pupae are characterized by a plump body, conspicuous red eyes, and a body wall with perpendicular edges. They are often ornamented with waxy thread-like projections.

LIFE CYCLE: The female lays from a few to 20 or more eggs in a circle on the underside of young leaves. As the eggs reach maturity, they turn from a creamy white to black. In approximately 5 to 10 days, the eggs hatch and crawlers emerge. The crawlers move a short distance from

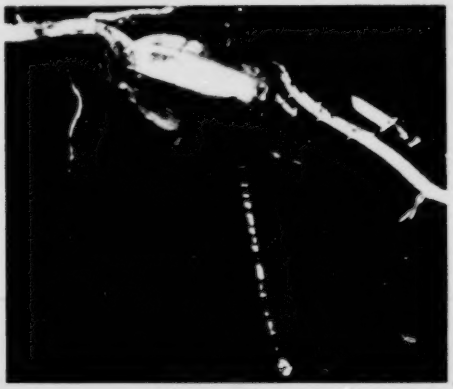
the hatching site and then settle to feed. With the first molt, the crawler loses its legs and therefore its ability to move from the feeding site. Pupation occurs after three additional molts. The winged adults emerge a week or two later. The adults are capable of laying eggs within 3 to 7 days of emergence. The whitefly is not known to overwinter out of doors in Massachusetts.

CONTROL: The whitefly is mainly a greenhouse pest and major outdoor outbreaks often originate from infested greenhouse grown transplants. Proper whitefly control should therefore begin in the greenhouse and transplants should be properly inspected and disinfested prior to moving them to the field.

WIREWORMS:

Several species may injure vegetable crops.

HOSTS: Corn, potatoes, and many other vegetable crops and root crops, small grains, grasses, weeds, etc.



Wireworm larva.

DAMAGE: Seeds may fail to germinate, as the larvae eat the seed germ. Seedlings are also attacked, resulting in thin and patchy fields. The worms also bore into the underground portion of the stems of transplanted crops, stunting and weakening them. Root crops such as potatoes, carrots, etc., may be seriously damaged by the tunnelling action of the worms.

DESCRIPTION: The larvae, are smooth wire-like worms, usually ½" to 1½" long. The larvae of some species are soft and white to yellowish, while others are dark brown and hard. They all have strong mandibles and 3 pairs of short true legs. The adults are brownish gray or nearly black beetles, very streamlined and about ½" long. They have a snapping structure on the ventral side enabling them to flip themselves over when placed on their backs—hence the name "click beetles".

Wireworm adult and larva.

LIFE CYCLE: The eggs are laid singly 1" to 6" deep in the soil in the spring. Hatching takes place in 2 to 4 weeks. Some species have a long life cycle and may remain in the larval stage for 5 to 6 years before pupating. There is much overlapping of generations so that all developmental stages and larvae of many sizes may be found in the soil at any one time.

CONTROL: Wireworms are becoming more common in cultivated fields. Whether or not this is due to a diminished use of pesticides with long residual life remains to be ascertained. The long life cycle of these pests makes them less likely to develop resistance to pesticides. Generally speaking, they are more prevalent in undisturbed fields previously in forage, grassland or in crops with long rotation periods. Sandy soils are more favorable to their development. It is highly advisable to ascertain the level of the larval population in relation to a given crop prior to the application of pesticides. Indiscriminate use of pesticides to soil may create a biological vacuum favoring the build-up of other destructive pests.

PESTS OF SPECIFIC CROPS

ASPARAGUS

ASPARAGUS BEETLE, *Criocerus asparagi* (Linnaeus)

HOSTS: Primarily asparagus.

DAMAGE: Both the adults and larvae may gouge out portions of the growing tips of the spears, rendering them unfit for sale. In addition, the adults lay unsightly black eggs on the spears which are difficult to remove. The insect may also attack the fern of old and new plantings.

Asparagus beetle, enlarged: a, adult beetle; b, egg; c, young larva; d, larva; e, pupa.

DESCRIPTION: The adult beetle, ¼" long, has a blue band down the middle, with lateral bands extending into yellow areas. The blue band often overtakes the yellow so as to leave only yellow spots (see illustration).

The outer border of the beetle is reddish. The slate black eggs are laid on end, singly or in rows. The soft, wrinkled grub-like larvae are 1/3" long, sluggish, olive green to dark grey, with black heads.

LIFE CYCLE: The asparagus beetle overwinters as an adult in rubbish, under bark and in other protected places, emerging to lay eggs about the time asparagus spears are being cut for market. The eggs hatch in a week. The larvae feed for approximately two weeks before dropping to the ground to pupate. New adults emerge ten days later. Two or more generations may occur each year.

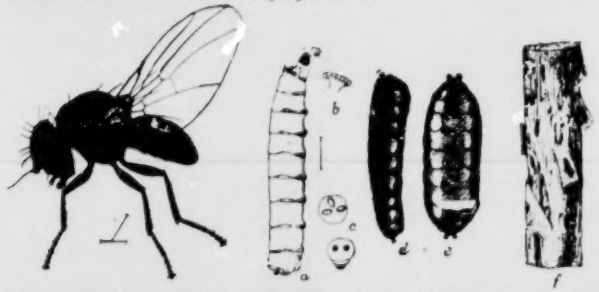
CONTROL: Control of the asparagus beetle is seldom necessary in New England, but strict vigilance for the possibility of outbreaks is suggested in order to apply proper control measures.

ASPARAGUS MINER,
Ophiomya simplex (Loew)

HOSTS: Asparagus and related plants.

DAMAGE: The larvae mine up and down the asparagus stem near the base of the plant. They may girdle the plant, causing the foliage to yellow and die prematurely. This injury may also favor the entry of soil inhabiting pathogens into the stem and crown of the plant.

DESCRIPTION: The adult is a small, metallic black fly about 3/16" long. The larva is a typical maggot, small, and white. Pupation occurs in the hardened and contracted larval skin or puparium.



Asparagus miner: adult fly, a, b, and c, larva with thoracic and anal spiracles; d and e, puparium; f, section of asparagus showing injury.

LIFE CYCLE: The insect overwinters as a pupa in tunnels made by the larva under the epidermis of the asparagus stem. The flies appear in late May and lay their eggs beneath the epidermis of the asparagus spears near or below the surface of the soil. The eggs hatch in 2 to 3 weeks and the larvae feed for about the same period of time before pupating. In July, the new adults emerge and give rise to the second generation. There are two generations per season, the second ending with the overwintering puparia.

CONTROL: This insect may favor the spread of stem rot of asparagus and its control may become necessary in new asparagus beds. Chemical means of control remain to be evaluated. At present, the destruction of infested plant parts in late fall, when feasible, may help eliminate most of the hibernating puparia.

SEE ALSO:

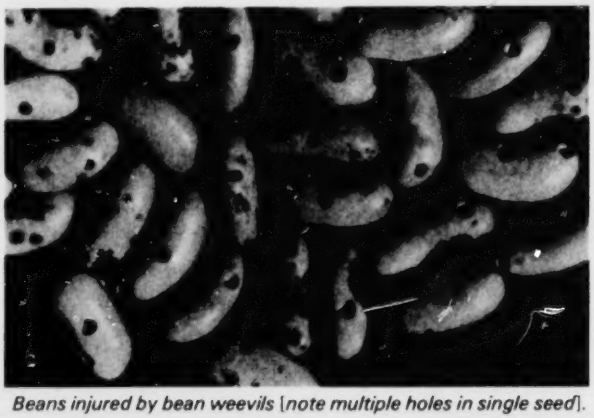
Cutworms, page 6.
Japanese beetle, page 12.
Wireworms, page 16.

BEANS

BEAN WEEVIL,
Acanthoscelides obtectus (Say)

HOSTS: Beans, white and kidney, lima beans, cowpeas, peas. Mainly a pest of stored seeds.

DAMAGE: This is primarily a storage pest, causing partial to complete destruction of the infested seeds. In contrast to the pea weevil, more than one larva of this weevil may enter a single seed and riddle it with holes (see illustration). The pest continues to infest seeds in storage.



Beans injured by bean weevils [note multiple holes in single seed].

DESCRIPTION: The adults are nearly square, 1/10" long and 1/8" wide, brownish black with lighter linear markings on the short wing covers. The white larvae are thick bodied, curved and legless, except in the first instar. Eggs are white and oval.

Bean weevil: a, beetle; b, larva; c, pupa.

LIFE CYCLE: The female can lay over 200 eggs, usually on stored seed. After hatching, the larvae enter the seed to feed for two weeks to six months or longer, depending upon the storage temperature and humidity. The pupal stage is passed in the seed, the adult emerging 2 to 8 weeks later. Breeding will continue steadily as long as there are seeds left in storage and the conditions are favorable. Northern temperatures do not permit the outdoor overwintering of this insect. Sporadic adult penetration of fresh pods may occur in home gardens. They leave small brown spots on the pods and the larvae feed on the seeds.

CONTROL: Use weevil free and sound seed. Fumigate seed lots with an approved fumigant. Store sound seed in weevil-free areas. (Heat treatment of seed should be limited to lots used for food.)

MEXICAN BEAN BEETLE,
Epilachna varivestis Mulsant

HOSTS: Bush, pole, cow, soy, lima and kidney beans, some forage crops and weeds.

DAMAGE: Both larvae and adults feed on the foliage, producing skeletonized foliage. A heavy attack may cause death of plants.

DESCRIPTION: The yellow to coppery brown adult is similar in shape to the lady beetle but larger in size (¼" in length). It has 16 black spots in 3 rows across the body. The pale orange elongated eggs are laid, like those of the lady beetle, in clusters of 40 to 50 or more, on the underside of the leaves. The young larvae are yellow to orange and covered with branching and black tipped spines (see illustration).

Mexican bean beetles feeding on the underside of a bean leaf. Clockwise from upper right; adult, pupa, full-grown larva, eggs, larva, immature larva.

LIFE CYCLE: The adult beetle usually overwinters among plant remnants on the ground, generally becoming active in the North in late May or early June, when the first eggs are laid. These hatch in about one week. Depending on weather conditions, the larvae will mature in 20 to 30 days. Pupation takes place on the underside of leaves and lasts about 10 days. Two or more generations may occur each year.

CONTROL: Quick growing varieties of green beans may suffer less injury. Remnants of crops should be plowed under soon after harvest, especially in the fall. Chemical control is often warranted.

SEE ALSO:

Aphids, page 5.
Cutworms, page 6.
Leaf miners, page 10.
Mites, page 11.
Potato flea beetle, page 38.
Seed corn maggot, page 31.
Six-spotted leafhopper, page 12.
Tarnished plant bug, page 13.
Wireworms, page 16.

CABBAGE, CAULIFLOWER, RADISH, RUTABAGA, TURNIP AND BROCCOLI

CABBAGE APHID,
Brevicoryne brassicae (Linnaeus)

HOSTS: Cabbage, turnip, broccoli and other crucifers.

DAMAGE: Large colonies may cause curling and crinkling of leaves. Honeydew secretion may give rise to copious sooty black mold. The mere presence of this insect may render sprouts and broccoli unmarketable.

DESCRIPTION AND LIFE CYCLE: The adult found on crop plants is generally wingless, greyish green, and covered with a powdery waxy secretion. This aphid may have several generations from April to October. It overwinters in the egg stage. A female may lay 80 to 100 living young.

CONTROL: This species is often kept in check by parasites (determine the incidence of whitish yellow leathery aphids, often showing the exit hole of the parasite) and by predators. Select varieties resistant or tolerant to this aphid. Chemical control may become necessary during wet summers.

CABBAGE LOOPER,
Trichoplusia ni (Huebner)

HOSTS: Cole crops in general, tomato, lettuce, potato, celery, etc. and a number of weeds and ornamentals.

DAMAGE: The young larvae feed on the undersides of leaves. Larger larvae feed more to the center of the plants. They feed voraciously from the edge of leaves inward and between veins as well, making large ragged holes in the foliage. They damage saleable parts of plants and foul them with excrement.

DESCRIPTION: The round greenish white eggs are smaller than a pinhead and ridged. The larvae are light green caterpillar with white stripes, up to 1½" long when mature. Instead of the five pairs of club-shaped prolegs typical of caterpillars, they have four pairs on the hind end of the body and for this reason "loop" when moving.

Cabbage looper: a, adult male; b, egg; c, larva [note looping position]; d, pupa in cocoon.

The pupa is copper colored and enclosed in a loosely woven cocoon attached to a plant or debris. The adult is a mottled greyish-brown moth with a wing span of 1½" and a silvery figure 8" in the middle area of each of the front wings (see illustration).

LIFE CYCLE: In Massachusetts, the larva of this insect is found on cabbage usually along with the imported cabbage worm and the diamond back moth. In contrast to the latter two pests, the looper does not hibernate in New England. The adults migrate yearly from southern areas

and are usually present in Massachusetts in late July. They deposit eggs mostly at night, singly and on the outer leaves of plants. The young larvae hatch 4 to 5 days later. They feed for 2 to 4 weeks before pupation, which lasts 10 days. Two to three generations can occur in one season. Local winter temperatures do not permit hibernation of this insect in the northern areas; however active populations may be encountered in greenhouses.

CONTROL: This insect has become resistant to a number of pesticides. *Bacillus thuringiensis* preparations are still effective against the larvae, especially when used in combination with contact insecticides. Surfactants or spreader stickers should be added to most spray formulations to improve plant coverage. Viral preparations for larval control are being evaluated.

CABBAGE MAGGOT,
Hylemya brassicae (Weidemann)

HOSTS: Cabbage, turnip, radish and other cole crops.

DAMAGE: The larvae (maggots) feed on the tap roots, storage roots and stem of the host plants. The infested tissue becomes riddled with tunnels excavated by the maggots. The entire underground portion of the plant may become honeycombed and rotten. Seedlings and transplants may easily be killed by the maggots. Older

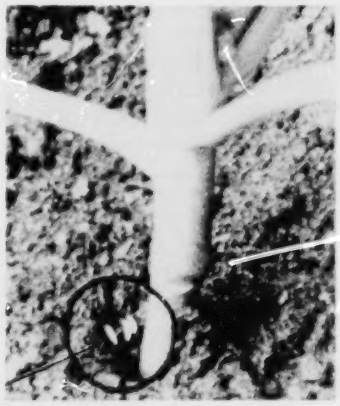
Cabbage root severely injured by the cabbage maggot. Two larvae and a pupa are shown.

plants may be severely stunted in their development and show severe wilting during warmer hours of the day. The infested plants usually have dull looking foliage. Radishes and turnip storage roots, although not killed, are rendered unmarketable by the feeding tunnels of the maggots.

The cabbage maggot fly.

DESCRIPTION: The white maggot is 1/4 to 1/3" long, blunt at the rear end and pointed at the head. The brown pupal case (puparium) is the size of a grain of wheat. The adult is a dark ashy grey fly, ¼" long, with black stripes on the thorax. It resembles the house fly but is smaller and quicker in its movements. The eggs are elongated and yellowish white (see illustrations).

LIFE CYCLE: The insect overwinters as a pupa buried 1" to 6" deep in the soil. In late April and May, the fly emerges, mates and deposits eggs at the base of field transplants or of seedlings in seed beds (see illustration). Hatching takes place in 3 to 9 days. The larvae feed for 20 to 30 days and pupate usually in the soil surrounding the host plants. The adults emerge in 10 to 14 days, usually in



Cabbage maggot eggs in natural position near stem of plant, [about natural size].

mid-July. A second generation may develop in July-August. The high seasonal temperatures at this time are usually less favorable to the insect. A fungus disease often decimates the adult population in mid-season. A third generation occurs with the onset of cool weather in September and October. These late maggot populations may cause severe injury to late planted rutabagas and turnips and give rise to most of the overwintering pupae. Outbreaks of maggots should also be expected on late planted cole crops and in mid-season if cool and humid conditions prevail.

CONTROL: Elimination of crop refuse, especially of root crops, and of wild hosts such as mustard may prove valuable. Rotation with non-host crops, when feasible, is also helpful. The selection of varieties of cole crops tolerant or resistant to the maggot is strongly suggested. Good soil fertility favors plant recovery from maggot injury. Chemical control measures are often necessary to protect cole crops from the maggot. The applications should be properly timed to prevent serious maggot outbreaks in seedling beds, on transplants, and in direct seeded fields. Proper surveillance, preferably by means of traps, will detect peaks of fly emergence, while the experienced eye will detect the eggs in the cole crop fields. Proper volume of drenching formulations of pesticides should be aimed at the base of the plants with the intent of saturating the surrounding soil down to the root ball. The required volume of formulation may range from 100 to 300 gallons per planted acre. Granular formulations of available pesticides have thus far provided a lesser degree of maggot control.

DIAMONDBACK MOTH,
Plutella maculipennis (Curtis)

HOSTS: Cabbage, broccoli, cauliflower, and other related crops and weeds.

DAMAGE: The caterpillars feed on the underside of leaves, making small holes which produce a shot-hole effect on the foliage. In dry seasons, they become abundant enough to cause serious damage. This insect is usually found on the host plants along with the cabbage looper and the imported cabbage worm.

DESCRIPTION: The adult female is a small greyish moth about 1/3" long, with folded wings flaring outward and upward at their posterior ends. In the male (see illustration), the folded wings form a row of three diamond-shaped yellow spots where they meet down the middle of the back — hence, the name diamondback moth. The moth moves rapidly when disturbed. Its flight is

The diamond back moth: a, male moth with wings folded; b, eggs; c, larva; d, pupa in flimsy cocoon.

a short hop from plant to plant. The yellowish-white eggs are very small and round, laid singly or in groups of two to three on the underside of leaves or on stalks. The mature larva is 1/3" long, pointed at both ends, pale greenish yellow with scattered black hairs over the body. It wriggles rapidly when disturbed and upon dropping, it hangs by a silk thread. The greenish pupa is enclosed in a fine, gauze-like cocoon (see illustration) fastened to the host plant.

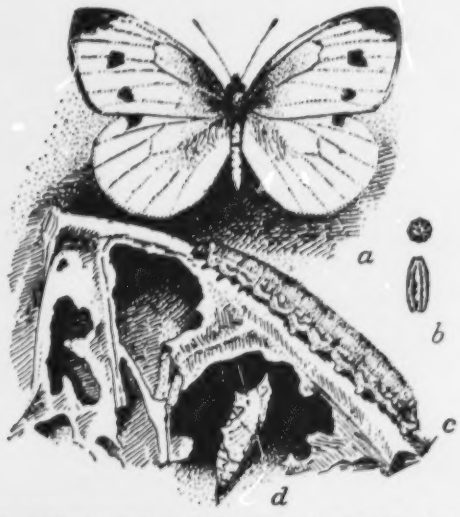
LIFE CYCLE: The moths probably overwinter in Massachusetts. Egg laying begins in the spring. The eggs hatch in a few days and the larvae feed and complete their development within 10 days to 2 weeks. The larvae then spin a loose gauzelike silken cocoon and change to pupae. The moths emerge within a week. As many as seven generations may occur at high summer temperatures.

CONTROL: See imported cabbage worm for control suggestions.

IMPORTED OR COMMON CABBAGE WORM, *Pieris rapae* (Linnaeus)

HOSTS: Cabbage, broccoli, cauliflower, brussels sprouts, turnip, radish, kale, lettuce, etc., sweet alyssum and weeds of the mustard family.

DAMAGE: Larval feeding riddles the leaves with large and irregularly shaped holes. The larvae may burrow into the saleable parts of the host plants. Excrement may stain edible parts and fragments may reduce the market quality of broccoli, sprouts, etc.



Imported cabbage worm: a, adult female; b, egg seen from above and from side; c, larva; d, naked pupa suspended by a silk strand.

DESCRIPTION: The larvae are very sluggish, dark velvety green worms. They are 1½" long, with five pairs of abdominal prolegs in addition to three pairs of anterior legs. The adult is the white butterfly tinged with yellow and having several black spots on the wings which is frequently seen flying in daylight hours in and near fields of cole crops. The pupa is greenish brown, naked, and attached by silk strands to the host plant or other sheltered locations. The yellowish egg, slightly elongated and marked with ridges, is attached to the host plant at one end.

LIFE CYCLE: The pest overwinters in the pupal stage on or near the host plant. The adult emerges in early spring. While flying in daylight over the fields, it alights occasionally to lay its tiny yellow eggs, singly, usually on the underside of the leaves. The eggs hatch in 5 to 7 days. The larvae feed for about fifteen days and then pupate. The adults emerge 10 days later. There are two to three generations per year in the north. The heaviest larval populations occur in July and August, often joined by the larvae of the cabbage looper and the diamond back moth. (Compare the appearance and habits of the larvae of the three pests.)

CONTROL: *Bacillus thuringiensis* may provide good control. Chemical control may be required in mid-season. Proper coverage of cole crops with spray formulations may be greatly improved by means of surfactants or spreader stickers. Uniform spacing of plants within the row and between adjacent rows greatly facilitates spray operations and assures uniformity of applications. Good weed control is also important.

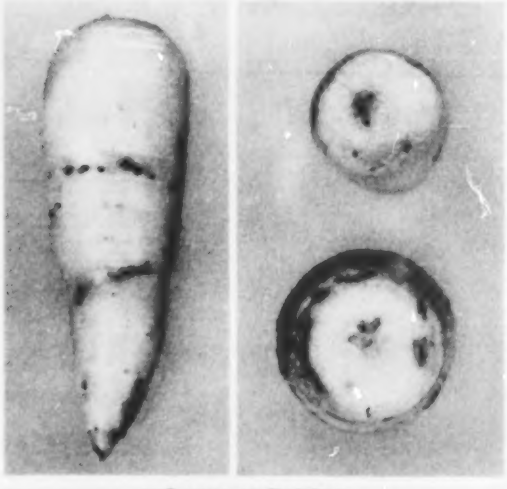
SEE ALSO:
Cutworms, page 6.

CARROTS, PARSLEY, PARSNIPS

CARROT RUST FLY, *Psila rosae* (Fabricius)

HOSTS: Carrots, parsnip, celery, parsley and dill.

DAMAGE: The maggots burrow into storage roots, impairing market value with their rust colored tunnels. The root system of young plants may also be injured. Drooping, discolored foliage indicates heavy maggot feeding. On celery, the maggots destroy many of the smaller roots.



Carrot rust fly injury.

DESCRIPTION: The adult is a shiny black fly less than 1/5" long, with a yellow-brown head and yellowish legs. The eggs are tiny and white. The slender yellowish maggot is 1/3" long and pointed at the front end. The brown puparium is about 1/5" long.

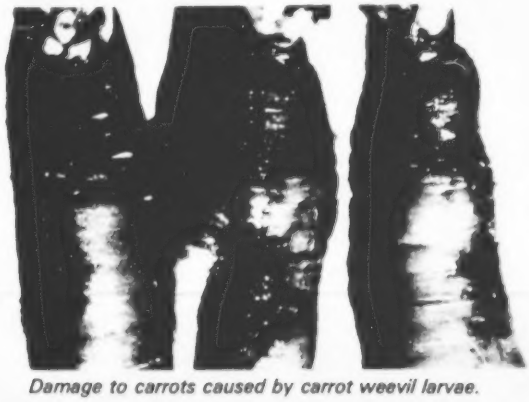
LIFE CYCLE: The winter is passed as a puparium buried in the soil where the host plants were grown. The adults emerge in early to mid-May and deposit their eggs singly or in groups on the host plant or on the adjacent soil. The maggots hatch 5 to 7 days later and feed for 3 or 4 weeks, then leave the roots and change into puparia in the soil. The new adults appear from mid-July to early August and lay the eggs of the second generation. The cycle of the second generation ends with the overwintering puparia. In some areas, a third generation has been reported.

Carrot rust fly larvae, pupae, and adults.

CONTROL: Rotation of crops may help, provided the new fields are as far as possible from previously planted areas. Deep plowing in fall or very early spring will aid in the destruction of overwintering puparia. Delaying seeding to avoid spring egg laying and harvesting the crop early in July before the emergence of the first generation flies may help avoid injury to crops. The August-September fly population still remains to be contended with and the maggots of this generation may continue to injure carrots even after harvest unless promptly placed in cold storage. Chemical control may prove practical and economical in endemic areas, provided that the applications are timed according to the local behavior of the pests.

CARROT WEEVIL, *Listronotus oregonensis* (Le Conte)

HOSTS: Carrot, celery, parsley, parsnips, dill, wild carrot, plantain and dock.

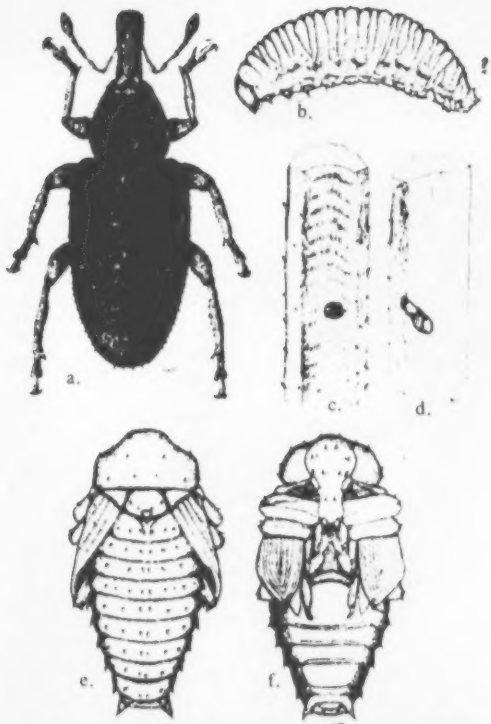


Damage to carrots caused by carrot weevil larvae.

DAMAGE: Larvae tunnel into the storage roots of the host plants, causing direct damage and favoring the entrance of pathogens. The injured roots are rendered unmarketable (see illustrations).

DESCRIPTION: The egg is yellow when first laid but turns almost black before hatching. Larvae, about ¼" long, are slightly curved ("C" shaped), legless and white to dirty white. The white pupae are slightly longer than the larvae and possess stiff spines. The adults are nearly ¼" long, black with a covering of tan scales. Dark scales for three faint stripes on the thorax and a mottling pattern on the wing covers.

LIFE CYCLE: This pest overwinters in the adult stage under crop residue or in woody areas adjacent to fields, etc. They become active during the month of May and migrate *by crawling* to the host plants. The insect rarely if ever flies. Egg laying begins in May but in Massachusetts the heaviest egg laying period is during the first 2 weeks of June. Eggs may be laid in the crown of the seedling, in the leaf petiole or in the portion of the carrot root immediately below the petiole attachment area. The larvae emerge approximately 6 days later and enter the carrot root where they feed for almost 2 weeks. Pupation occurs in the soil and the new adults emerge approximately 9 days later. The complete life cycle lasts an average of 50 days. Normally, only one complete generation develops in this area, ending with the hibernating adults. A partial second generation may develop on late planted carrots.



Carrot weevil: a, adult; b, full grown larva; c, egg cavity in carrot leaf stock; d, section, exposing eggs; e, pupa, dorsal view; f, pupa, ventral view. [A. M. Boyce]

CONTROL: Since the weevil has rarely been seen to fly, crop rotation in areas of suspected weevil hibernation or of previous infestation may be beneficial. Removing cull carrots from cultivated areas is highly advisable.

Chemical control may be confined to the periphery of fields to provide a barrier to adult migration from known overwintering quarters. Direct treatment of crops, when

Carrot weevil eggs deposited at crown of seedling.

necessary, should be timed according to the local behavior of the beetle and receptive stage of development of the crop. The local entomologists will provide the necessary information for proper timing of applications.

SEE ALSO:

Onion thrips and other species, page 36.
Six-spotted leafhopper, page 12.
Wireworms, page 16.

CORN (SWEET)

COMMON ARMYWORM,
Pseudaletia unipuncta (Haworth)

HOSTS: All grass crops, corn in particular, some legumes and a large number of weeds.

DAMAGE: The insect is a heavy foliage feeder in spring and early summer. Damage usually begins at the side of a field and can spread quickly to the entire planted area before the farmer becomes aware of the infestation. The common armyworm like the stalk borer causes heavy damage to and fouling of the corn whorl; however, the

Larva, frass and damage of a, common armyworm and b, common stalk borer.

common armyworm does not tunnel into the stalk. Often, armies of undetected larvae move from area to area as the food supply becomes depleted. On corn, the larvae of this insect are found simultaneously with those of the stalk borer and of the first generation corn borer. It is important to learn to differentiate between these larvae and to become familiar with their habits and the type of plant injury they cause.

Common armyworm adult.

DESCRIPTION: The mature larva is 1½" long, greenish yellow to brown, with a dark, almost black longitudinal stripe along each side and a broad stripe down the back. This stripe has a fine, light colored broken

line running down its center (see illustration). The head is pale brown with a green tinge, mottled with dark brown. The brownish grey adult has a wingspan of 1½", with a tiny white spot near the middle of each front wing and a dusky outer margin on the hind wings (see illustration). The adults are strong night flyers and may migrate for many miles when aided by prevailing winds.

LIFE CYCLE: In Massachusetts, the common armyworm overwinters either as a nearly mature larva or as a pupa. These two stages are sheltered in the soil, in clumps of grass or under litter. Adult emergence, egg laying and larval feeding begin in the spring. The white eggs, the size of a pinhead, are deposited in masses or rows on shaded parts of plans. One female may lay 500 or more eggs. Small greenish caterpillars hatch in 8 to 10 days. It takes 7 to 8 weeks for the insect to develop from egg to adult. There may be 2 to 3 generations per year; however, the spring and early summer generations are the most destructive to vegetable crops and particularly corn, in Massachusetts. The reader should compare the characteristics and life cycle of this insect with those of the fall armyworm, corn earworm, common stalk borer and European corn borer which are also described in this manual.

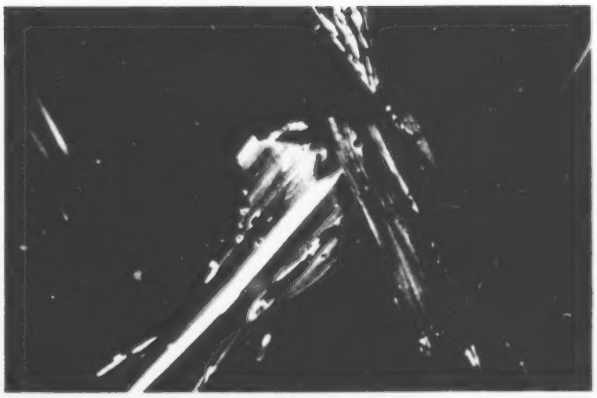
CONTROL: Seasonal conditions, predators and parasites may influence the severity of the armyworm infestation in spring-early summer. As a rule, the infestation originates in grassy areas surrounding cultivated fields or in weedy areas within the fields. These areas should be watched carefully during the spring and early summer months to detect the caterpillars before they reach the destructive migratory stage. The top growth of the host plants should be parted at random and the lower growth examined carefully for the presence of the tiny green worm. The whorls of the young corn plants should be inspected for damage and the presence of larvae. Strip application of chemicals to grassy areas surrounding the fields may act as a barrier against the migration of these worms to planted fields. Surveillance for outbreaks may be complemented by monitoring the number of the night flying moths attracted to light traps. On corn the chemical control measures against the stalk borer and first generation European corn borer are also applicable to the common armyworm.

FALL ARMYWORM,
Spodoptera frugiperda (J.E. Smith)

HOSTS: Usually corn and many other vegetable crops as well as forage crops such as alfalfa, clover, etc.

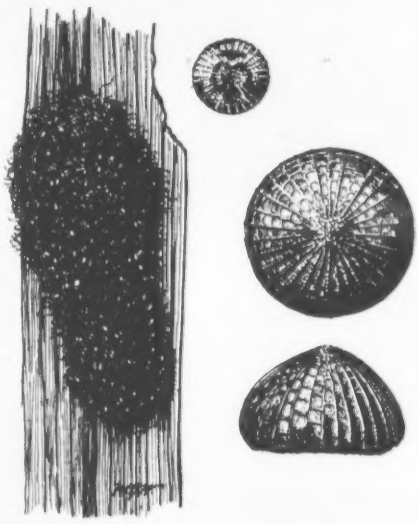
DAMAGE: The fall armyworm is a serious pest of corn in the Northeast, occurring mainly in late summer to fall. Whorl and ears of corn can be extensively damaged by the larvae, which when found in corn ears, are often confused with the corn earworm. The damage to the whorl is similar to that of the common armyworm. It is important to learn the seasonal occurrence of various species of caterpillars on corn in the Northeast.

DESCRIPTION: The full grown larvae vary in color from light tan or green to nearly black. They have three yellowish-white hair lines down the back from head to tail. On the sides, next to the outer yellow lines, is a wider dark stripe and next to it an equally wide, somewhat wavy



Fall armyworm damage with larva.

yellow stripe splotched with red. These larvae can be distinguished from the larvae of the common armyworm by the presence of an inverted Y-shaped suture on the front of the usually black head (see illustration), by the more slender and darker body, and by the longer hairs arising from prominent black tubercles. In contrast to the fall armyworm, the larvae of the corn earworm may range in color from green to pink to a brownish black when fully grown. The head of the earworm larva is reddish brown with paler patches and the body is large and stout. The adult moth of the fall armyworm has a wingspan of about 1½". The hind wings are greyish white and the front pair dark grey, mottled or variegated with lighter and darker splotches. A considerable variation in coloration may occur among adult populations.



Eggs of the fall armyworm.

LIFE CYCLE: The fall armyworm is not known to overwinter in any developmental stage in areas where the ground freezes; therefore, all infestations occurring in the northern areas are mainly due to summer migration of adults from southern areas. They lay the longitudinally ribbed white eggs in clusters on plants and non-living objects. They hatch within 2 to 10 days. The larvae feed for approximately 20 days before entering the soil to pupate. In Massachusetts, there is only one generation, beginning

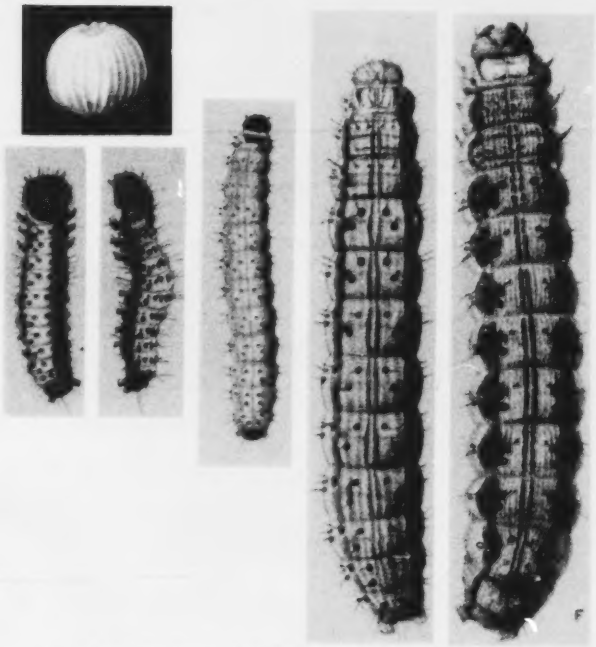
in late July, often coinciding with the appearance of the corn earworm and the second generation of the European corn borer.

CONTROL: Clean cultivation is of importance. Weeds surrounding growing areas may attract the fall armyworm and constitute a major source of infestation of cultivated crops. Chemical control measures against the corn earworm and the second generation European corn borer are also applicable to the fall armyworm.

Adult billbug and its damage to corn foliage.

CORN EARWORM, *Heliothis zea* (Boddie)

HOSTS: Sweet corn, beans, lettuce, alfalfa, clover, vetch, tobacco, geranium and several other crops, ornamentals and weeds. When found on tomatoes, it is known as the "tomato fruitworm". In the Northeast, it is considered one of the most serious pests of sweet corn.

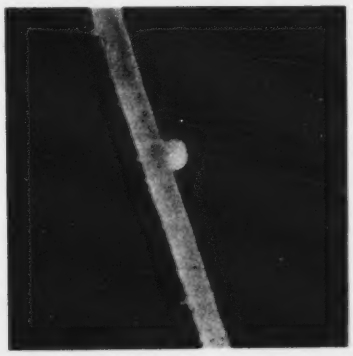


Corn earworm. Egg, early and late instar larvae.

DAMAGE: The larvae feed in the corn ear, devouring mostly the apical kernels and fouling them with frass. The voracious larvae may also destroy the corn silk before pollination is completed but are rarely found feeding on the foliage of corn in the Northeast. On tomatoes, the larvae bore into the fruits, on beans they feed on the foliage and pods. Due to their cannibalistic instinct, the larvae are usually solitary.

DESCRIPTION: Fully grown larvae are stout, about 1½" to 2" long and vary in color from light green to pink and from brown to almost black. They have a yellow head and light and dark stripes and bands running the length of the body. The body is lighter on the underside. The stripe in the middle of the back is a double line. The hairy and stout adult moths are strong fliers and are capable of long migrations. They are light buff to reddish brown, with irregular dark lines, or bands and often with a black spot near the posterior margins of the forewings. They have a 1½" wing span. The round yellow eggs are half the size of a pinhead and are strongly ridged lengthwise. They are deposited singly on fresh corn silk or on foliage, fruit, etc. The reddish brown pupa is about 1" long. See illustrations of life stages and learn to differentiate them from those of other related pests of corn.

LIFE CYCLE: The corn earworm overwinters as a pupa 2 to 6" below the soil surface. Although there are some indications that the pupa may survive the winter in Massachusetts, it is generally accepted that most of the adult population migrates to the Northeast mainly from southern regions. The adult is a very strong flier and has been caught at high altitudes in aerial surveys.



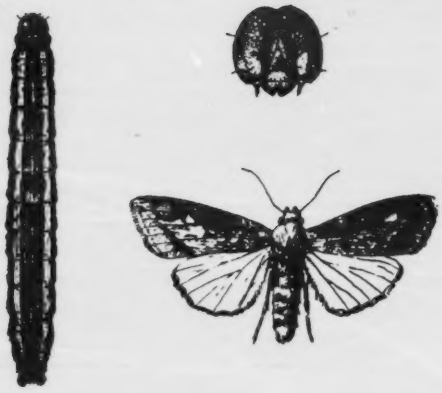
Corn earworm egg attached to sweet corn silk.

The established adults fly at dusk and are usually caught in light traps beginning in mid-July in southern Massachusetts. The eggs are laid singly on corn silk and other plant parts. The female may deposit 1000 or more eggs during her life span. The young feed voraciously for 3 to 4 weeks before entering the soil to pupate. Development from egg to adult requires about 30 days in midsummer and longer in autumn. There may be 2 overlapping generations in the North, ending with the overwintering pupae, whose ability to survive the winter in the Northeast is still unknown.

CONTROL: Preventative chemical control of this highly destructive and prolific insect is commonly carried on in sweet corn fields in the Northeast as soon as the first moths are found in monitoring light traps or when the first eggs are detected on corn silk in the southernmost regions. During periods of major infestations, repeated applications of pesticides at 48 hour intervals may become necessary to protect corn ears. Pest management methodologies for the control of this pest are being developed according to local conditions.

The reader is advised to become familiar with the illustrations and descriptions of other pests of corn provided in this manual.

Larvae and Adults of Major Lepidopterous Pests of Corn

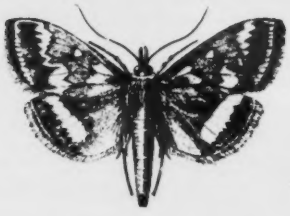


a, common armyworm

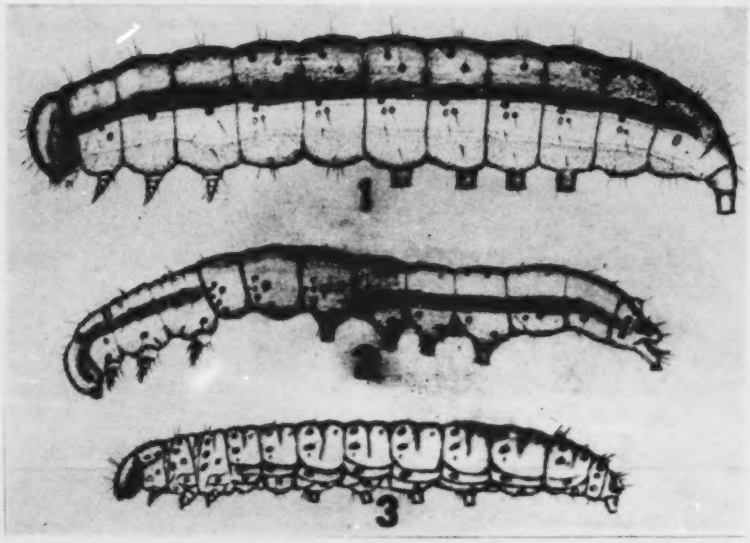
b, fall armyworm [notice inverted "Y" suture on forehead of larva]

c, corn earworm

d, common stalk borer [variety nitela]



e, European corn borer



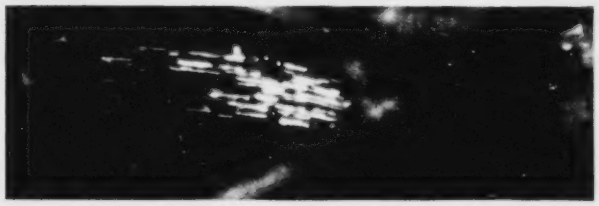
f, larvae of: [1] corn earworm, [2] common stalk borer, [3] European corn borer.

CORN FLEA BEETLE OR BRASSY FLEA BEETLE,

Chaetocnema pulicaria Melsheimer

HOSTS: Corn, sorghums, small grains, grasses, etc.

DAMAGE: The feeding of the adult causes elongated yellow stripes in the green portion of the leaves (see illustration). Severely damaged leaves look bleached. The beetle is the major winter reservoir and vector of Stewart's wilt disease or bacterial wilt of corn. The overwintering beetles may transmit the disease to 2 to 3 week old corn seedlings. The severity of the disease usually depends upon the variety of corn and the number of beetles that overwinter successfully.



Corn flea beetle and damage.

Corn flea beetle.

DESCRIPTION: The bronze colored adults are roundish, about 1/16" long, with distinctly enlarged and thickened hind legs (see illustration). They jump when disturbed. The greyish white larvae are small with brown heads.

LIFE CYCLE: The beetle overwinters in the adult stage. A larger number usually are able to overwinter when the sum of the mean temperatures for December, January, and February is about 100°F (37-38°C). The adults emerge in the spring to mate. The eggs are laid mainly on the ground near the base of the host plant. The larvae are root feeders. There may be 1 to 2 generations per season.

CONTROL: Clean cultivation is important since the beetles also feed on many weeds. Late planting of corn and the selection of wilt resistant corn hybrids will decrease losses from Stewart's wilt. After mild winters, chemical control may be warranted on young plants from spring through early summer to diminish bacterial wilt transmission.

CORN LEAF APHID,

Rhopalosiphum maidis (Fitch)

HOSTS: Corn, barley, millet and other wild and cultivated plants of the grass family (Graminaceae).

DAMAGE: A major pest of sweet corn in Massachusetts. This aphid colonizes the tassels and upper leaves of the plant, as well as flag leaves of ears. Leaves may show yellow mottling to reddish patches of discoloration. Ears and flag leaves of infested plants may be covered with honeydew and sooty mold, thus rendering the crop unmarketable. Heavy honeydew on silk may also interfere with proper pollination. The corn aphid is a vector of the maize dwarf mosaic virus and other viruses.

DESCRIPTION AND LIFE CYCLE: Members of the colonies of this aphid are greenish blue. Both winged and wingless females are usually present. This species is thought to be a southern migratory pest. The overwintering egg stage has not been found in Northern areas.

CONTROL: Chemical control of this aphid may become necessary in mid-season. The maize dwarf mosaic may be controlled only by means of resistant or tolerant varieties, if and when available.

EUROPEAN CORN BORER,

Ostrinia nubilalis (Huebner)

HOSTS: Corn, potato, pepper, bean, celery, and several other vegetable crops, chrysanthemums, gladiolus, and other ornamentals. Several weeds such as pigweed, ragweed, goldenrod, etc.

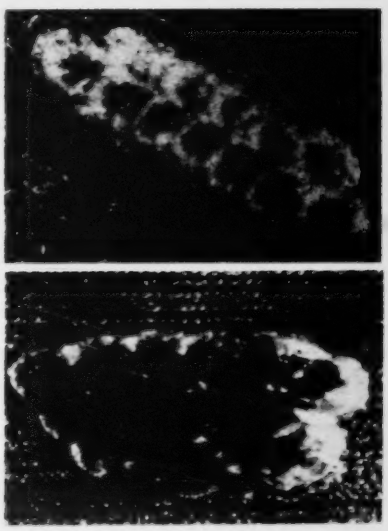
DAMAGE: This is the most important pest of corn in Massachusetts. First generation (June-July): As a rule, the young larvae of the first generation cause light damage to the foliar whorl. Later instars penetrate the tender stalk,

Damage to tassel and ear of sweet corn caused by European corn borer. [Note holes and frass on damaged areas.]

causing tassel breakage and weakening of plants. Some of the larvae may also penetrate into the corn ears, either through the shank or by lateral migration from the stalk. Common armyworm and stalk borer may also occur at this time. Second generation (mid-July-September): All the larval stages of the second generation may attack the

corn ears directly through the silk channel and cause serious damage, often in conjunction with corn earworm and fall armyworm. Cannibalism prevents the occurrence of the three species in the same ear.

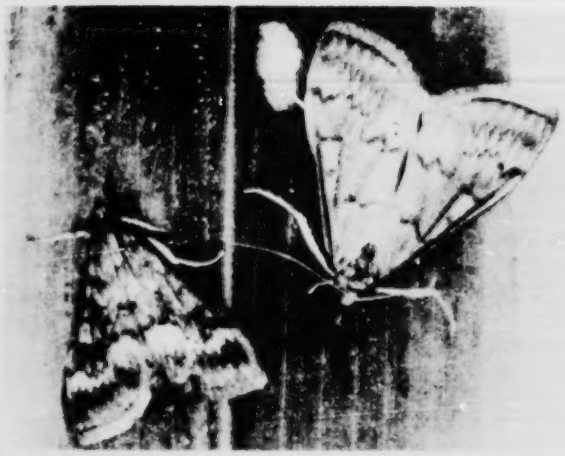
DESCRIPTION: The adult at rest is triangular in shape. It has a wing span of 1¼" and is approximately ½ to ¾" long. The female moth is pale yellow to light brown with darker wavy lines and bands across the front wings. The front wings of the male are reddish brown with zig-zag yellowish bands. The female moth is usually larger than the male and has a stouter abdomen. The eggs are disc-shaped, pinhead in size and laid in masses of about 20 overlapping, like shingles on a roof. The newly laid eggs are yellowish. Prior to hatching, they become black, due to heads of the young larvae showing through. Upon hatching from the egg, the larva is a tiny 1/16" long whitish caterpillar with a black or dark brown head. After 5 molts, the larva reaches a length of approximately ¾" and ranges in color from dirty white to light brown, with a pale pink tinge. It has a faint brown line along the middle of the back and scattered round small brown spots (see illustration). The pupa is naked, ½ to ¾" long, dark brown when mature.



Eggs of European corn borer. Above: newly laid. Below: ready to hatch.

LIFE CYCLE: Mainly on corn (See illustrations.) The full grown larva overwinters mainly in the stems of the host plants as well as in corn ears, stubble, storage cribs, etc. The overwintering larvae pupate mostly in May of the following year. In Massachusetts the adults begin to emerge usually during the first week of June and may be found in the field until late June, or early July. The moths mate within 24 hours of emergence. Their flight is short and erratic and occurs at dusk and dawn, at temperatures above 60°F. During the day, they may be flushed from weeds around and within the fields.

First generation (June-July): Egg laying: It begins in early June, about 3 days after mating and continues on a large scale for 14 to 18 days. A female may lay an average of 500 eggs. The eggs are laid on the underside of the bottom leaves of corn plants in the whorl stage and hatch in about 3 to 7 days.



Adults ofEuropean corn borer. Female above with egg mass; male below.

Exposed larval stages: The first instar larvae (an instar being the stage between two molts) are 1/16" long. The instar lasts about 7 days. On corn, the young larvae migrate to the center of the whorl and feed on the tender leaves until the green tassel appears. The first larval molt occurs while the larvae are still in the whorl. The resulting second instar larvae are 1/8" long. They usually feed on the buds of the now emerging green tassels, boring into them and tying several buds together with silk, forming a protective tunnel in which they feed. A considerable amount of frass is found on the outer surface of these tunnels. This is the most opportune time for the application of pesticides to destroy the still exposed larvae prior to their penetration into the stalk.

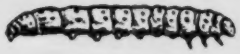
Boring larval stages: These larvae are mostly beyond the reach of pesticides. The second molt is completed about 5 days after the first. The resulting third instar larvae are 3/16" long and soon begin to bore into the main branches of the available corn tassels or penetrate into the tender stalk, usually at the base of the leaves. Within 5 days, the 3rd molt is completed and the resulting 4th instar larvae, approximately 1/2" long, tunnel up and down the stalk, causing the typical tassel breakage usually associated with early summer corn borer damage.

The fourth molt takes place approximately 7 days later and the resulting 5th instar larvae up to 3/4" long, complete their development in 10-15 days. During this period, the larvae become wanderers. They start new tunnels or enter the ears through the shank or through the husks but seldom through the silk channel (compare this behavior with that of the second generation larvae). Usually only 25 to 30% of the corn plants with stalk infestation may suffer ear damage as well. Pesticide applications may offer only a mediocre protection to the corn ears against these wandering larvae.

Pupation occurs in the stalk or ears and lasts about 8-10 days. The moth emerges from the pupal chamber through a hole in the plant made by larvae prior to pupation. The main emergence of the first generation adults takes place from mid- to late July in Massachusetts. (Some larvae within the population may have as many as eight instars

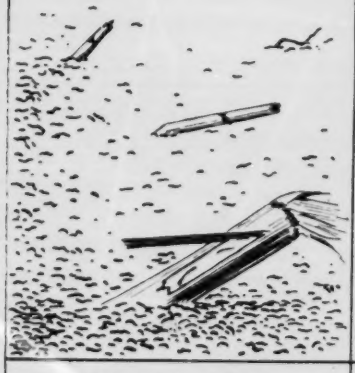
MAY

OVERWINTERING BORERS CHANGE TO RESTING STAGE (PUPAE) IN OLD CORN AND WEED STALKS AND SIMILAR SHELTER



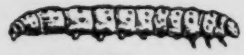
THE BORER

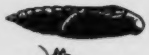
RESTING STAGE OR PUPA NATURAL SIZE

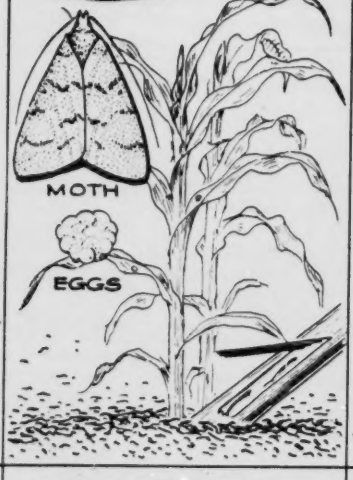


JUNE

LAST OVERWINTERING BORERS PUPATE. PUPAE CHANGE TO MOTHS. MOTHS LAY EGGS AND FIRST-BROOD BORERS BEGIN TO HATCH

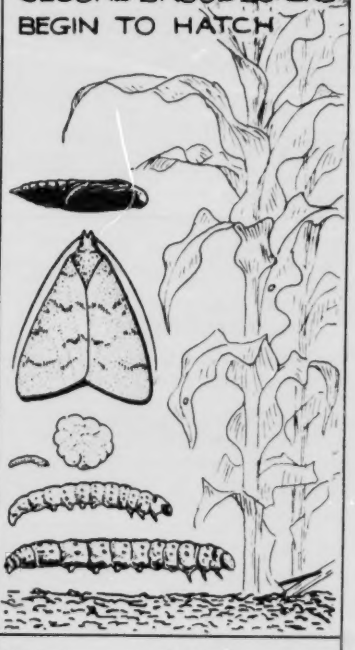






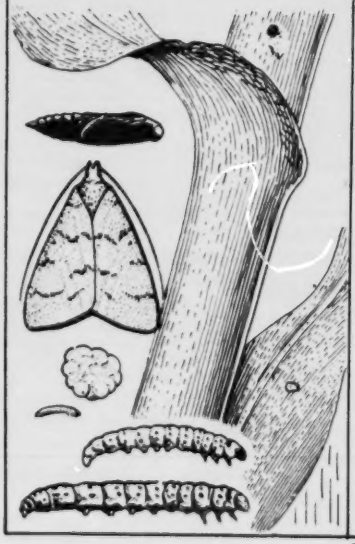
JULY

SOME FIRST-BROOD BORERS PUPATE AND CHANGE TO MOTHS. MOTHS LAY EGGS. SECOND-BROOD BORERS BEGIN TO HATCH



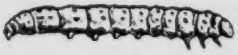
AUGUST

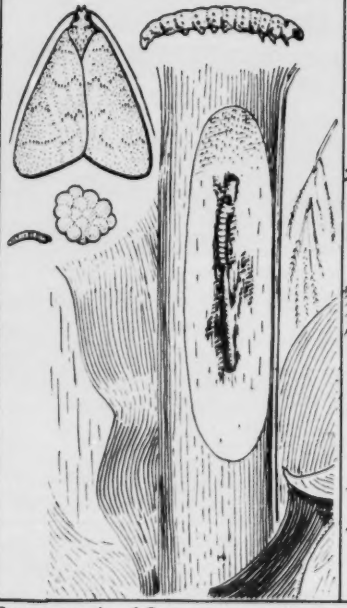
LAST OF FIRST-BROOD BORERS PUPATE AND CHANGE TO MOTHS. SECOND-BROOD BORERS CONTINUE TO HATCH



SEPTEMBER

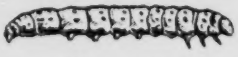
SECOND-BROOD BORERS COMPLETE THEIR GROWTH

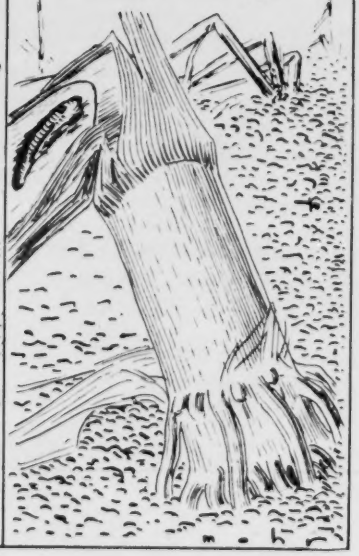




WINTER MONTHS

OCTOBER THRU APRIL FULL-GROWN BORERS WINTER IN CORN STUBBLE AND STALKS OF CORN AND WEEDS





Season cycle of European corn borer.

and some may undergo a summer diapause of undetermined duration. Preliminary observations indicate that some of these diapausing larvae may go through the winter. These biological abnormalities are essential for safeguarding the survival of the species.)

Second generation (late July to September): Eggs of the second generation borers are found in Massachusetts in early August. The larval development is basically similar to that described for the first generation. The major difference is in their feeding habits in that all the larval instars of the second generation show clear preference for the corn ears which are plentifully available at this time of the growing season. With the onset of low fall temperatures, the larvae of the second generation enter diapause. They go through the winter as mature larvae in dead stalks of host plants, in debris, etc., and give rise to pupae and moths in May-June of the following year. Illustrations are provided in this manual for distinguishing the corn borer larva from larvae of related pests found on corn.

CONTROL: Mechanical and cultural: Most of the borer's larvae are found in corn stalks at a height of 6" from the ground surface. Consequently, short stubble will leave fewer borers overwintering in the field. Fall plowing is more desirable for achieving this reduction. The plowing should be thorough and deep, with no trash left on the surface. Early spring plowing (not later than May 1) may induce the hibernating larvae to come to the surface and fall prey to natural enemies. Ensilage cutters chopping stalks into small sections are very effective in destroying a large number of larvae.

Time of planting: Timing the planting of corn to avoid early summer infestations is not always practical because the early corn has the highest cash value; however, as a rule, mid-season harvests may escape the brunt of the infestations.

Biocontrol: The incidence and efficacy of naturally occurring parasites and predators in Massachusetts remain to be ascertained.

Chemical control on corn: Contact insecticides applied for the control of first generation larvae should be directed into the whorl and onto the early green tassels to eliminate the exposed larvae before they bore into the stalk. Proper coverage to include the bottom of the whorl's funnel is imperative to achieve proper control. These suggestions are applicable for the control of the stalk borer and the common armyworm whose larvae also attack corn in the whorl stage. It is important to learn to distinguish between these three pests, their larvae and the damage they cause. Insecticide applications against the second generation larvae should be directed mainly at the silking ears and accurately timed to destroy the larvae prior to their penetration into the silk channel. The number of applications will depend upon the duration of the silking process and also upon the seasonal incidence of larvae of the corn earworm and fall armyworm, which have similar habits and usually occur contemporaneously with the second generation larvae of the European corn borer. The protection of other crops should also be timed to eliminate the young larvae before they penetrate into the plant parts, e.g. potato vines, pepper fruits, and stems, etc. Pest management methodologies applicable to the corn borer under Massachusetts conditions remain to be evaluated.

NORTHERN CORN ROOTWORM, *Diabrotica longicornis* (Say)

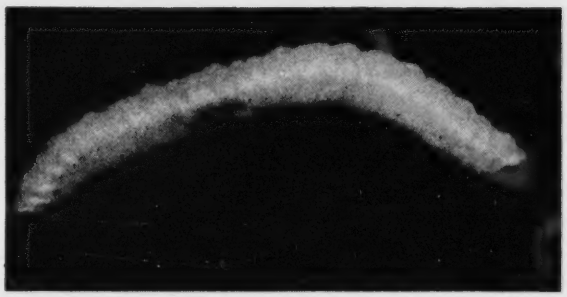
HOSTS: Mainly corn.

DAMAGE: The larvae tunnel into the larger roots and crown of corn plants. The plants are weakened and stunted and are easily blown down ("lodging") by strong winds and heavy rainfall. This pest is also a vector of bacterial wilt and other pathogens of corn. The adults may feed heavily on fresh silk, thus interfering with proper pollination.

Left: normal corn root system. Right: root system destroyed by larvae of northern corn rootworm.

DESCRIPTION: The thread-like larvae are white to pale yellow worms, about ½" long when mature, with brown heads and short legs. The eggs are very small and difficult to locate in the field. The pupa is typical of beetles (see illustration of white grub pupa). The adult beetles are scarcely ½" long and uniformly pale green to yellowish green.

LIFE CYCLE: The winter is passed in the egg stage in corn fields. These overwintering eggs usually hatch in June of the following year. The young larvae migrate through the soil to feed in or on the corn roots and crowns of the plants. The larvae will die of starvation if corn plants are not present. Pupation takes place in the soil. The adults emerge during late July to early August and may be present in the fields, actively feeding on corn silk, until frost. They will lay the overwintering eggs on stalks and under soil clods, debris, etc. There is only one generation per year.



Typical corn rootworm larva.

Northern corn rootworm. Adult.

CONTROL: As the larvae of the northern rootworm feed mainly on the roots of corn, severe outbreaks may occur if this crop is grown in the same soil for several years in succession. Elimination of corn for one year usually results in the starvation of the larvae deriving from the overwintering eggs. Conditions of drought and low fertility render the corn plants less capable of recovery from attack. Some varieties of corn are more capable of recovery by quickly replacing injured root systems. Shallowly planted corn is more prone to lodging.

Southern corn rootworm. Adult.

Chemical control with soil insecticides should be adopted only if the locally established economic threshold of infestation has been surpassed. Indiscriminate use of soil pesticides may lead to other complications (see wireworms and white grubs).

PLEASE NOTE: The southern corn rootworm, *Diabrotica undecimpunctata howardi* Barber, a yellowish green beetle with eleven dark spots on the wing covers, is seldom a pest of corn in the Northeast. It has a life cycle different from that of the northern corn rootworm. It overwinters in the adult stage and the larva feeds on a number of crops. Therefore crop rotation is not effective against the southern corn rootworm.

SAP BEETLES, Dusky Sap Beetle, *Carpophilus lugubris* Murray, and Corn Sap Beetle, *C. dimidiatus* (Fabricius)

HOSTS: These beetles may be serious pests of sweet corn.

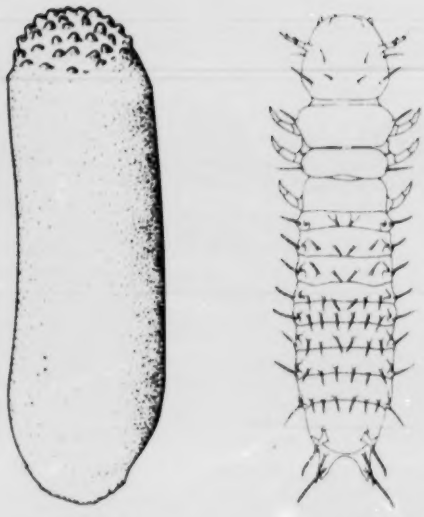
DAMAGE: Adults and larvae may feed on corn kernels causing fouling and decay.

DESCRIPTION: *C. lugubris:* The adult is an oval shaped, 1/8" long beetle with wing covers shorter than the abdomen and club shaped antennae. It is usually dark brown to black. The white larvae are ¼" long and spiny, with six legs.

C. dimidiatus: The adult may vary from black with a reddish tinge to brownish yellow, with an orange spot on wing covers. Larvae are as described above.

Sap beetle damage to corn. [Note larvae and beetles.]

Adult dusky sap beetle.



Egg [1] and larva [2] of the dusky sap beetle.

Corn silk fly larvae [do not confuse with larvae of sap beetle].

LIFE CYCLE: Adults may hibernate in soil, under debris, etc. Early in the season, they may feed on rotten organic material, fermenting vegetation, tree sap, etc. Later, as the corn silk begins to dry, they move to the corn plants to lay eggs on the silk, on exposed kernels of ears with loose husks, or on ears which have been damaged by earworm and other insects or by birds. The larvae feed actively on the kernels until maturity and then drop to the ground to pupate in the soil. Several generations may occur in the field.

CONTROL: Chemical control measures against the corn borer, the corn earworm and other insects injuring corn ears are also effective against the sap beetles. Avoidance of varieties with loose husks and elimination of rotting plant material from corn land will reduce the incidence of infestation as well as the size of the overwintering beetle population. Bird control should be practiced with locally approved means, if warranted.

SEED CORN MAGGOT,
Hylemya platura (Meigen)

HOSTS: Seeds and seedlings of corn, beans, peas, squash, cucumber, cabbage, turnip, beets, radish, and many other crops, as well as seed potatoes, clover and alfalfa roots, etc.

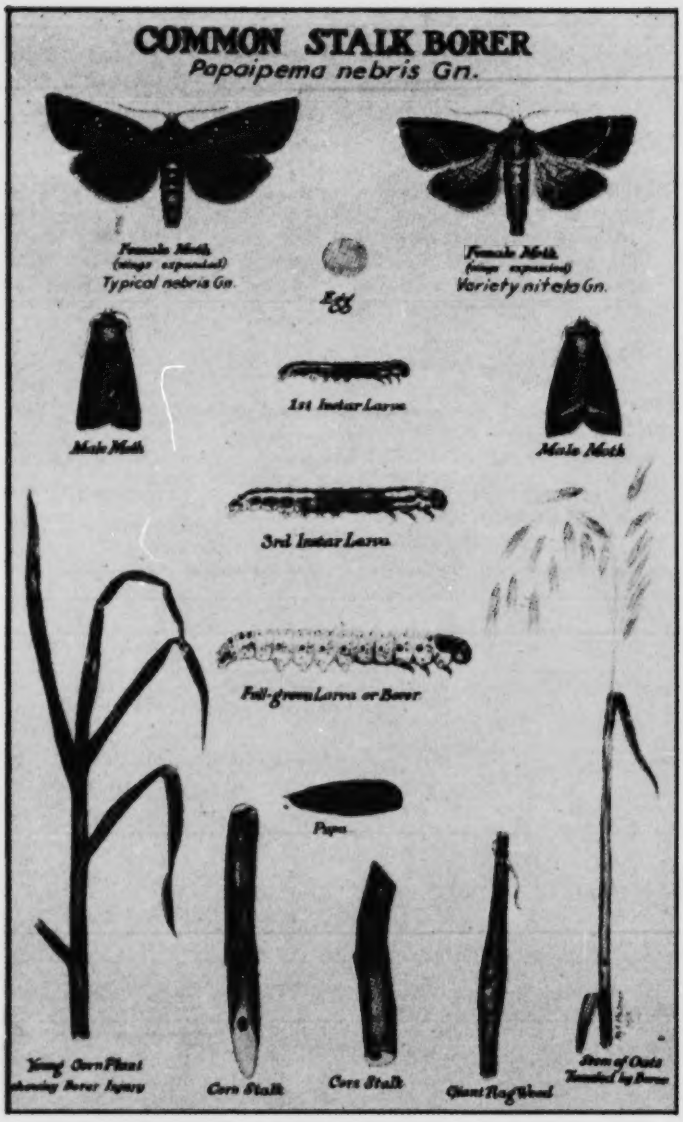
DAMAGE: The sprouting seed (root, hypocotyl, cotyledon) is attacked by the maggot. The direct damage caused by the maggot together with the contemporaneous introduction of pathogens result in dead and/or deformed and weakened plants. Abundance of organic matter in the soil and a cool and wet season favor the development of the maggots in seed beds as well as in direct and deep seeded fields.

Seed corn maggot damage to bean seedlings.

DESCRIPTION: The adult is a small greyish-brown fly about 1/5" long, smaller than a housefly. It does not have the dark bands on the thorax which characterize the cabbage maggot. The maggots, when fully grown, are yellowish white and about ¼" long, with a body shape tapering sharply towards the head. The brown puparium is shorter and thicker than the larva and equally rounded at each end.

Life stages of seed corn maggot.

LIFE CYCLE: The puparium is the overwintering stage. The first adults are seen very early in the spring. Eggs are laid in moist soil, preferably rich in organic matter. They hatch in 3 to 5 days. Egg hatching may occur at



Common stalk borer. Life stages.

temperatures as low as 50°F. The larvae complete feeding in two or three weeks. Pupation occurs in the soil. The first generation adults appear towards the end of May and into June. There may be 2 or more generations a year and pupae of the last generation overwinter in the soil. The injury by larvae of the second generation is usually less severe.

CONTROL: When feasible, planting should be delayed until the maggots of the first generation have pupated, i.e. usually in early to mid-June. Avoid the use of organic fertilizer in endemic areas. Improve drainage. Seed as shallowly as possible and promote quick germination and vigorous growth. Use seeds treated with an approved insecticide-fungicide combination. When treating your own seed, always add a fungicide to prevent insecticide injury to seed. Soil applications of pesticides soon after seeding may prove beneficial in endemic areas.

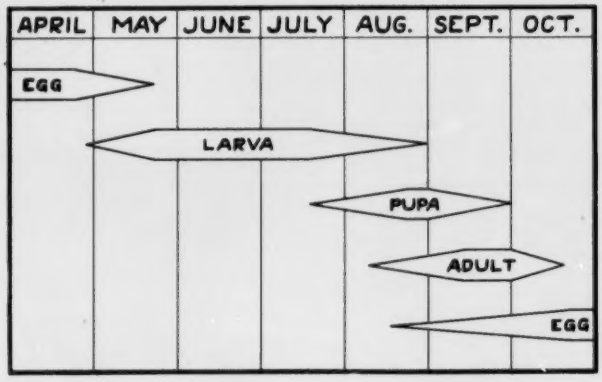
STALK BORER, *Papaipema nebris* (Guenee)

HOSTS: Primarily corn and potatoes and numerous weeds. More than 100 species of host plants have been reported.

DAMAGE: Corn: Foliage of whorl shows raggedly chewed areas with copious amounts of frass and large fecal pellets (see also common armyworm). The worm hides in the leaf folds and later penetrates the tender stalk. The emerging green tassel is also damaged. The stalk borer is rarely found feeding on corn ears. Compare the habits and damage caused by the stalk borer with those of the corn borer, common armyworm, fall armyworm and corn earworm. Potato: The worm tunnels into potato vines causing wilting of foliage and death of the vine.

DESCRIPTION: The mature egg, approximately 1/50" in diameter, is light brown, round and heavily ridged. The young larvae are brown with a single continuous white stripe down the back and two white stripes on each side of the body, interrupted by a darker median area approximating ¼ of the body length (see illustration). In the mature larvae, the stripes fade out and the body coloration changes to a creamy to light brown. The larva may reach 2" in length at maturity. The pupa is naked and brown. The moth of the typical stalk borer has a wing span of approximately 1½". It has fawn grey front wings marked with two clusters of whitish spots (see illustration for variety *nitela*). The hind wings are smoky in color. Learn to differentiate the stalk borer larva from those of other corn pests.

LIFE CYCLE: This insect has one generation per season. It overwinters in the egg stage. The eggs are laid from August to September between blades of grass or leaves of weeds in groups of 15 to 50 or more. The night flying female may lay up to 1500 eggs in her 10 to 30-day life span. The overwintering eggs hatch the following May or June. The young larvae feed mostly on grasses and



Seasonal history of the common stalk borer.

weeds during their early stages of development and later move to potato, corn, and other plants with large stems or stalks. They may migrate from plant to plant to satisfy their food requirements. The larvae usually undergo 7 to 8 instars in approximately 40 to 60 days. (As many as 16 instars have been recorded under conditions unfavorable to normal larval development.) Pupation takes place in the host plant's stalk or in a pupal cell in the ground. The

emergence of adults will occur in late August and September. It is at this time that the overwintering eggs are laid.

CONTROL: The suggestions given for the control of the larvae of the first generation corn borer and of the common armyworm also apply to this insect. Weed control, whenever practical, is very helpful in reducing larval populations of the insect as well as the incidence of the overwintering eggs.

SEE ALSO:

Corn blotch leaf miner, page 11.
Cutworms, page 6.
Japanese beetle, page 12.
Mites, page 11.
White grubs, page 13.
Wireworms, page 16.

CUCUMBER, SQUASH, MELON, PUMPKIN

SQUASH BUG, *Anasa tristis* (De Geer)

HOSTS: Squash, especially winter varieties, and pumpkin. Occasionally, melon and cucumber.

DAMAGE: The feeding by sucking sap and injection of toxic saliva cause wilting of small plants. The leaves of older vines under severe attack become black and parched. Entire vines may be killed and plants may be severely stunted.

Squash Bug: five nymph stages & adult.

DESCRIPTION: The adult is a dark brown true bug finely mottled with grey or light brown, about 1" in length (see illustration). The clusters of bright brown, oval eggs are conspicuous against the green undersides of the leaves on which they are laid. Young nymphs are green to reddish and wingless. They change to dark brown and grey and develop wing pads as they mature (see illustrations of life stages of the tarnished plant bug).

LIFE CYCLE: The adult may overwinter indoors as well as outdoors under rubbish, near buildings, etc. Usually, in June, groups of a dozen or more eggs are laid on the lower surface of the leaves of the host plants. Hatching occurs in about 10 days. The nymphs mature in four to six weeks. There is one generation per year. Only the adults overwinter.

Squash bug eggs on underside of squash leaf.

CONTROL: Select varieties of squash resistant to the squash bug. Soon after harvest, vines should be collected and destroyed so as to eliminate bugs that might go into hibernation. Weeds and rubbish should also be cleared so that minimum shelter is offered to the hibernating adults. Chemical control should be aimed at the younger nymphs, usually found feeding in large clusters. These are much easier to kill than the more solitary larger nymphs and adults.

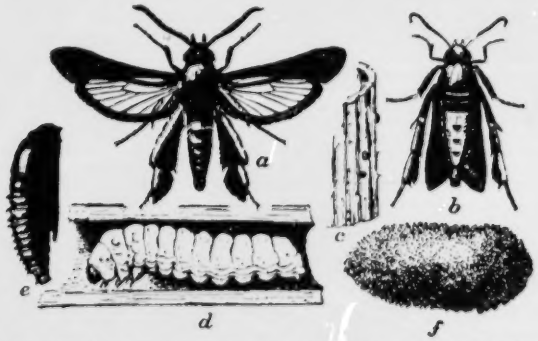
SQUASH VINE BORER, *Melittia cucurbitae* (Harris)

HOSTS: Hubbard squash is highly susceptible: a great variation in the degree of susceptibility to this insect is found among varieties of squash, gourd, melon, cucumber, and pumpkin. Butternut squash has been reported to be immune to this insect.

DAMAGE: The larvae tunnel into stems, beginning near the base of the plant. Fruits may be attacked as well. The sudden wilting of a vine and the presence of sawdust-like excrement coming from holes along the vine indicate the presence of boring larvae. If infested plants survive, yield and quality of fruit will be inferior.

DESCRIPTION: The white larvae, when fully grown, are over 1" in length with a dark head, brown legs and a stout body. The moth has a wing span of 1½", glistening brownish forewings and transparent hindwings. The hind legs are fringed with black and orange hairs. The abdomen and legs are brick red. The moths are often mistaken for wasps (see illustration).

LIFE CYCLE: The mature chubby white larva as well as the brown pupa overwinter in the soil. Adults emerge in early summer and are most active during warm days. They lay brown eggs from mid-June to early July on the stems of plants, mostly near the base of main stems. The hatching larva bores into the vines, and after feeding for four or more weeks, pupates in the soil, where it remains until the following spring. There is one generation per year in the North.



The squash vine borer: a, male moth; b, female moth with wings folded at rest; c, eggs shown on stem; d, full grown larva in vine; e, pupa; f, pupal cell.

CONTROL: Chemical control, when warranted, should begin in early summer (mid-June through July) before the larvae enter the stems. All crop remnants after harvest

should be raked together and destroyed. Soil should be harrowed in late fall to unearth the larvae and pupae hibernating in the cocoons located ½" below soil surface.

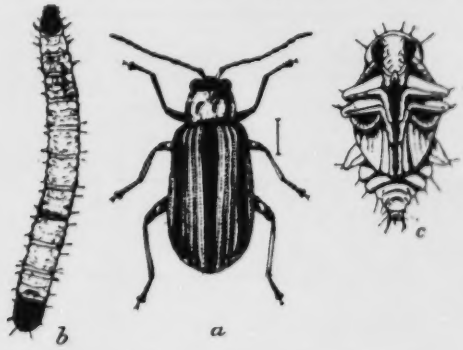
STRIPED CUCUMBER BEETLE,
Acalymma vittatum (Fabricius)

HOSTS Squash, cucumber, melon, pumpkin, etc.

DAMAGE: These beetles may attack the young host plant injuring hypocotyls and cotyledons. They later feed on vines, leaves and fruits of mature plants. The beetles are also vectors of bacterial wilt and mosaic viruses. The larvae feed on plant roots.

Striped cucumber beetle and feeding damage.

DESCRIPTION: The adult beetle is 1/5" to 1/4" long with a black head. The wing covers are yellow-green with 3 longitudinal black stripes. The orange-yellow eggs are laid near the base of the host plants, often below the soil surface or in cracks in the ground. The slender white larva, reminiscent of a rootworm, is about 3/8" long and darker at both ends. They have three pairs of short legs.



Striped cucumber beetle: a, adult; b, larva; c, pupa.

LIFE CYCLE: There is only one complete generation of this pest in the North. Only unmated adults overwinter, usually in neighboring woodlands, under fallen leaves, strips of bark, or rotten logs. The adults are usually in close contact with the soil while overwintering. They emerge in the spring when the temperature is above 55°F. If cucurbits are not available as host plants, the beetle will feed on the pollen, petals, and leaves of willow, apple, hawthorn, elm, and other related plants. Mating and egg laying take place as soon as the cucurbits become available. Eggs hatch in approximately 10 days. The larvae work their way into the soil and feed on the plant roots for 2 to 6 weeks before pupating in soil cells. The adults emerge in 7-10 days.

CONTROL: Chemical control is aimed mainly at the adult populations. Several applications may be required to protect host plants in seedling to fruit bearing stages.

SEE ALSO:

Aphids, page 5.
Cutworms, page 6.
Garden springtail, page 9.
Leaf miners, page 10.
Mites, page 11.
Seed corn maggot, page 31.
Six-spotted leafhopper, page 12.
Wireworms, page 16.

LETTUCE

LETTUCE ROOT APHID,
Pemphigus bursarius (Linnaeus)

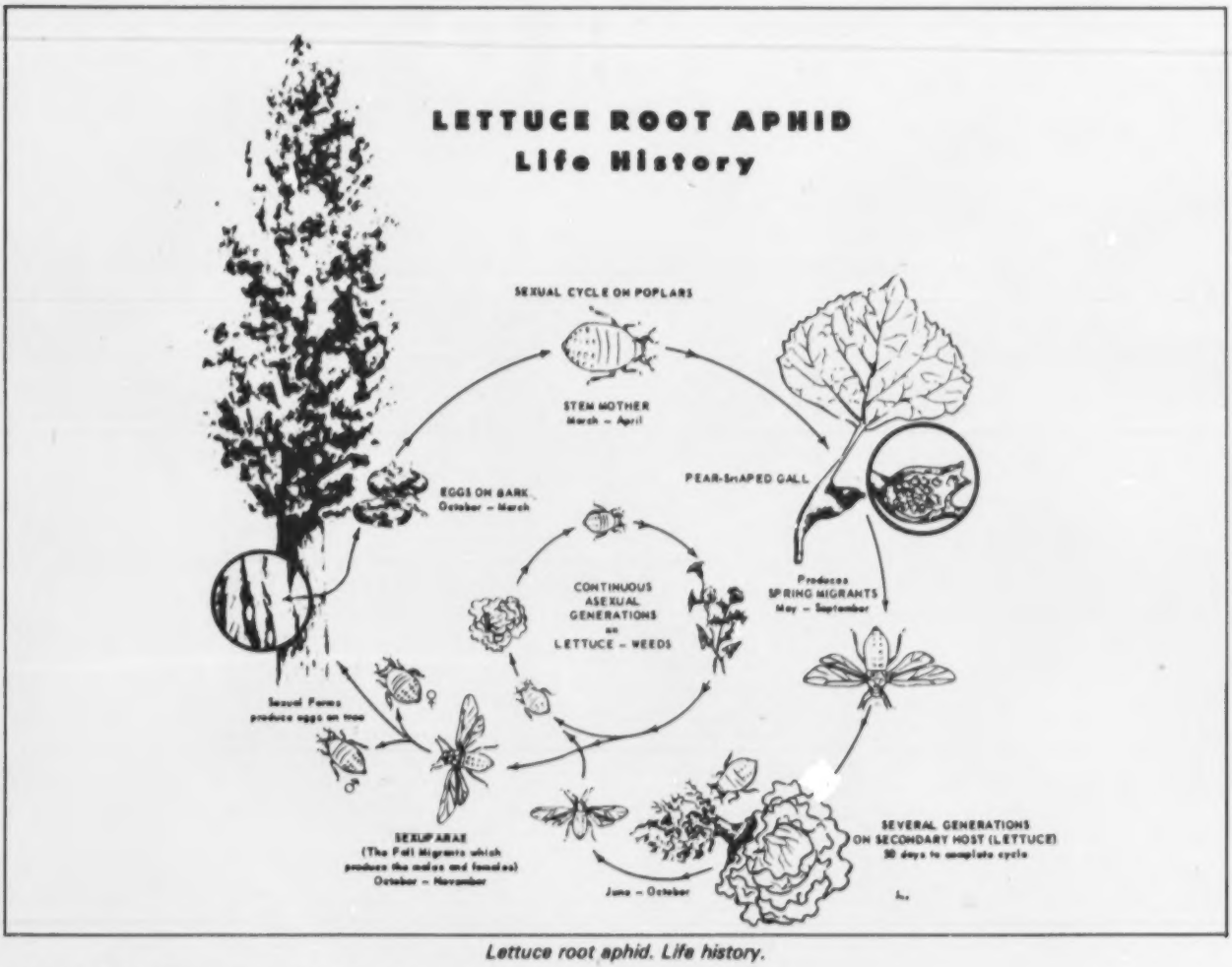
HOSTS: Lettuce and related weeds. In the west, the primary host receiving the overwintering eggs is usually the Lombardy poplar; the primary host of this aphid in the Northeast has not been ascertained.

DAMAGE: Wilting of outer leaves of lettuce plants is usually the first indication of extensive root damage caused by the aphid. The wilting is particularly evident during the warmest part of the day. Developing lettuce heads remain soft, or fail to develop properly. Under severe infestations, wilting is followed by the collapse and death of plants. This aphid is becoming a serious pest of lettuce in Massachusetts.

DESCRIPTION: The insect secretes a waxy, wool-like material. Upon digging out infested plants, masses of the white woolly material can easily be seen on the plants' roots and surrounding soil; from 500 to 5000 aphids have been reported to occur on one plant.

LIFE CYCLE: In the west, the aphid overwinters in the egg stage in bark crevices of the Lombardy poplar. In March, the hatching young feed on the poplar's new growth. Plant galls form around the feeding aphid (see illustration). Winged migratory forms develop within the galls. They emerge to fly to lettuce seedlings and reach their root systems through soil crevices. They give rise to numerous parthenogenetic generations of wingless root-feeding females. The mated females migrate back to the Lombardy poplar in the fall to lay the overwintering eggs. There are indications that the parthenogenetic forms may also overwinter in the soil or on the root systems of host plants present in the field during the winter season. The aphid reproduces continuously and parthenogenetically under greenhouse conditions. The complete life cycle of the insect in the Northeast remains to be determined.

CONTROL: If an infestation has occurred on the previous year's crop, the soil should be worked deeply and repeatedly, if possible, and allowed to dry thoroughly before replanting lettuce. Shallow rototilling of infested fields before replanting is not adequate to eliminate the aphid populations. If the lettuce can be made to grow rapidly, a satisfactory crop can often be produced in



Lettuce root aphid. Life history.

infested fields. Repeated cultivation in early season to eliminate soil cracks may impede and/or delay the aphids' access to plant roots. Tolerant varieties of lettuce are under evaluation. The control of this aphid with the chemical means presently available is difficult and often disappointing.

SEE ALSO

Cabbage looper, page 18.
Cutworms, page 6.
Green peach aphid, page 6.
Six-spotted leafhopper, page 12.
Slugs, page 13.
Wireworms, page 16.

ONION

ONION MAGGOT, *Hylemya antiqua* (Meigen)

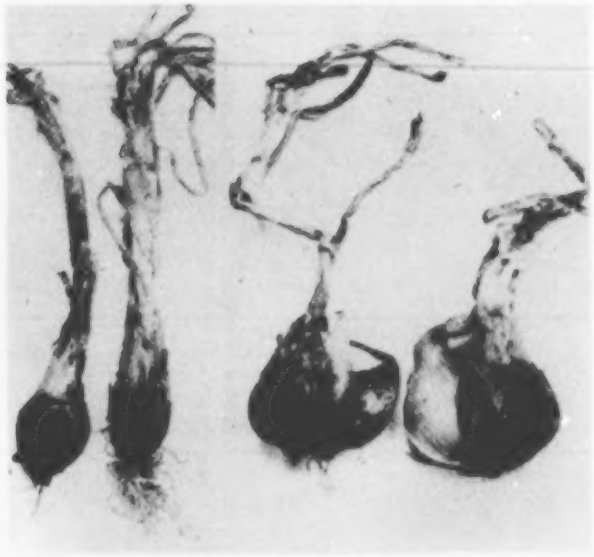
HOSTS: Onions and related plants.

DAMAGE: Bulbs injured by the maggot are also made susceptible to pathogens. Injured seedlings wilt and die.

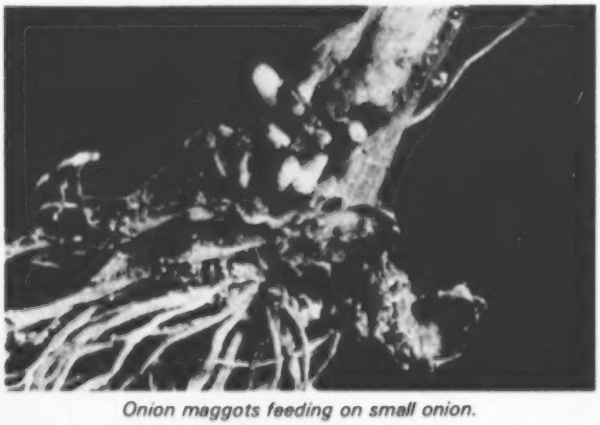
DESCRIPTION: The larvae are typical white legless maggots. The adult, the egg, and the puparium resemble those of the seed corn maggot.

LIFE CYCLE: The pupa (in a puparium) hibernates concealed in the soil or sheltered among weeds or crop remnants. The adults begin to emerge in the spring, usually in mid-May, to lay eggs near or on the host plants. The eggs hatch in less than a week. The larva feeds for 2 to 3 weeks, then pupates in the soil for approximately 2 more weeks. The emerging adult will give rise to a second generation. Cool wet weather favors the development of 2 to 3 generations. The seasonal cycle ends with the hibernating pupae.

CONTROL: Cull onions should be removed from the onion field and never plowed under or piled on or near the onion fields. Soil rich in organic matter is attractive to the insect, especially during wet and cool seasons. White varieties of onions are more attractive to the insect. Chemical control should start with seed treatment, which should always consist of a combination of an insecticide and a fungicide to protect seed germination. Pre-planting



Onion maggot injury to small and mature onions.



Onion maggots feeding on small onion.

Onion maggot: adult, pupa and larva.

soil applications of pesticides may reduce the number of females emerging from hibernating puparia. Soil applications at planting time will protect seedlings and/or bulbs from maggot infestation during cool, wet springs and falls. These treatments should be repeated as needed, preferably as band applications.

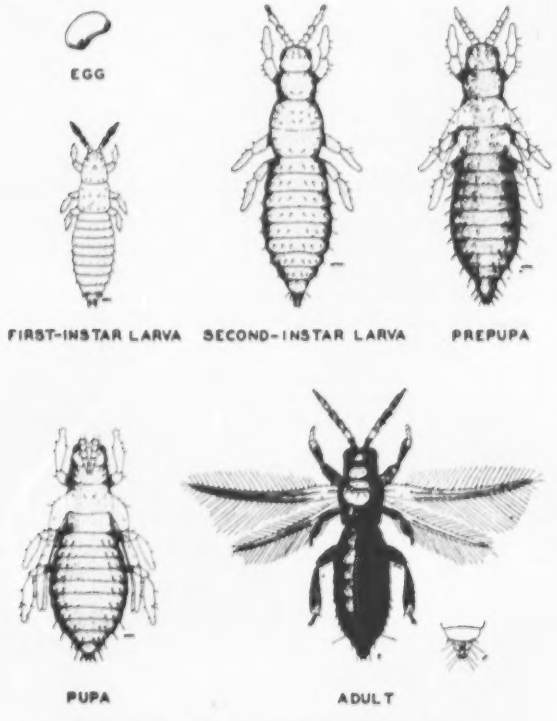
ONION THRIPS, *Thrips tabaci* Lindeman

HOSTS: A major pest of onions, it attacks more than 200 species of plants.

DAMAGE: The feeding of thrips produces white to silverish blotches on the leaves, a condition known as "Silver Top" of onions. It is caused by the sucking-rasping mouth parts of the adults and larvae. Under severe infestation, the plants look bleached and stunted. Bulbs make little growth. Green onions are rendered unmarketable. On seed crops, the insect may severely reduce seed production.

DESCRIPTION: The winged adults are shy and quite small, about 1/25" long, ranging in color from light yellow to light brown. The wingless white larvae usually hide under leaf sheaths. The white, bean-shaped eggs are thrust into the leaves. (See illustrations of all the stages of development of this insect.)

LIFE CYCLE: This thrips may overwinter as a diapausing adult and/or larva under rubbish in the field. Active populations may occur all year round on different host plants in greenhouse and on stored bulbs. The first eggs, laid in the field in May-June, hatch in 5 to 10 days. The young mature in 15 to 30 days, passing through four stages, two of which, the prepupa and pupa, are spent in the soil without feeding. The emerging female returns to the plants to lay up to 100 eggs. There may be several overlapping generations per year and all stages of development can be found in the field from June to September.



Typical life stages of thrips. [Terebrantia].

CONTROL: The destruction of all crop residue after harvest followed by fall plowing may reduce the number of overwintering thrips. Early planting, clean cultivation, and the selection of tolerant (Spanish type) and early maturing varieties are also helpful. The planting of onion sets near fields of older plants or near infested greenhouses should be avoided. When planning the chemical control of this pest with contact insecticides, it must be remembered that the insect's eggs and nymphs hide under leaf sheaths

and pupation takes place in the soil. Repeated applications with proper plant coverage may be necessary to reduce the thrips population, especially during warm and dry weather in July-August. In areas where the insect is a major pest of onions, these applications must be initiated in early June or as soon as first indications of damage or presence of thrips are observed.

PEAS

PEA APHID, *Acyrthosiphon pisum* (Harris)

HOSTS: Peas, beans, alfalfa and many other legumes, other vegetable crops, weeds, etc.

DAMAGE: This species is able to multiply rapidly in early summer. Large populations may cause yellowing, wilting, and stunting of plants and pods. It is also a major vector of bean mosaic virus.

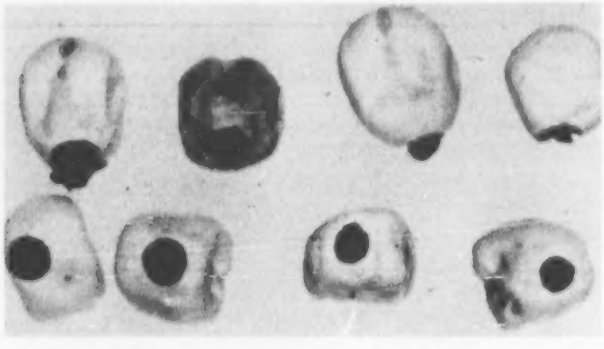
DESCRIPTION AND LIFE CYCLE: The adult is light to deep green, with red eyes. Leg and cornicles are tipped with yellow. It overwinters mostly in the egg stage. The species has several generations per year, mainly in spring, early summer and fall. (For life cycle, see aphids.)

CONTROL: Some varieties of peas have shown tolerance to pea aphid attack. Bean varieties resistant to mosaic are also available. (For additional control suggestions, see green peach aphid.)

PEA WEEVIL, *Bruchus pisorum* (Linnaeus)

HOSTS: Peas

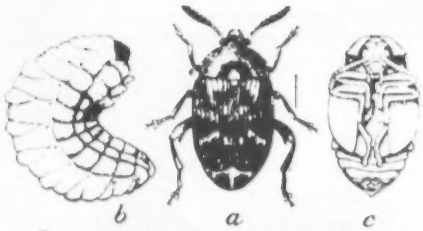
DAMAGE: A single larva feeds inside a pea seed, lowering or destroying the viability of the seed and its marketability.



Pea seed showing pea weevil injury. [Note single exit hole.]

DESCRIPTION: The adult is a short, chunky beetle, 1/5" long and brownish, flecked with white, black, and greyish patches. The wing covers do not reach the end of the abdomen. The white larva is thick-bodied, curved, and legless. The pupa is typical of beetles. Eggs are elongated and yellowish.

LIFE CYCLE: The adult overwinters in or outside the seed, in the field or in storage. The females feed on pollen and plant parts and may lay from one to a dozen or more eggs on a pod, which hatch in 5 to 18 days. The larvae enter the pod and a single larva penetrates a seed, feeding from 4 to 6 weeks. Pupation occurs in the seed and lasts a



Pea weevil: a, adult; b, larva; c, pupa.

week or more. Prior to pupation, the larva makes an exit tunnel up to the seed coat but not through it. The adult emerges by chewing its way through the seed coat or remains in the seed until stored. The infestation may therefore go undetected up to the adult stage. This insect does not develop in dried peas and therefore there is no population increase in storage.

CONTROL: Discontinue cultivation of peas for 1 to 2 years. Use weevil-free seed. Plow under or destroy debris and residue of crops soon after harvest. Fumigate seed soon after harvest. Chemical control should be timed in the field according to the incidence of adults. Usually the adults begin to migrate to the fields when the peas are in bloom.

SEE ALSO:

Bean weevil, page 17.
Cutworms, page 6.
Seed corn maggot, page 31.
Six-spotted leafhopper, page 12.
Wireworms, page 16.

PEPPER

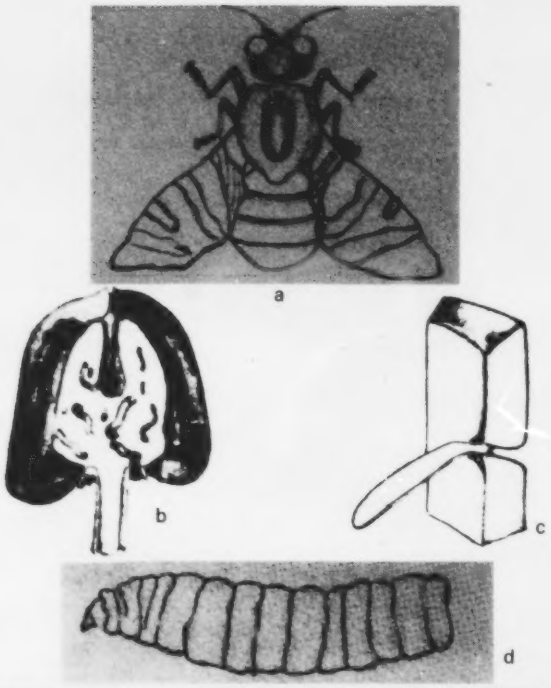
PEPPER MAGGOT, *Zonosemata electa* (Say)

HOSTS: Peppers, especially varieties with a large spongy core, as well as cherry, squash and bull nose varieties; on occasion eggplant and tomatoes are infested. Among the weeds, the fruit of horse nettle is sought by the fly.

DAMAGE: The maggot feeds within the fruit upon the core, inner wall and immature seeds. A single maggot may render a fruit unfit for market as well as ruin its value for seed or for processing. Dropping of early set fruits caused by the maggot is often overlooked.

DESCRIPTION: The adults are two-winged, brightly colored yellow-striped flies, approximately the size of a housefly. The head, thorax, legs and abdomen are yellow, the eyes are green, and the wings clear with brown bands. The maggot resembles a sharply pointed peg and is a transluscent white in its early stage, turning yellow as it matures. The eggs are large, opaque white and have the shape of a summer crookedneck squash. The puparium is the typical hardened and contracted larval skin, brown when mature.

LIFE CYCLE: This pest overwinters in the soil as a pupa. The adults begin to emerge in June and may still be found in the field until August. The eggs are deposited in the wall of the pepper. A female may lay up to 50 eggs. Hatching takes place 8 to 10 days later. The larvae feed on the core, immature seeds and wall tissue for 10 days to 2 weeks. When mature, they exit through the stem end of



Pepper maggot: a, adult; b, larva feeding on pepper core wall and immature seeds; c, egg inserted in pepper wall; d, larva.

the pepper and drop to the soil, where they pupate and hibernate at a depth of 2 to 4" until the following season. There is usually one generation per year.

CONTROL: Areas of distribution of the fly should be carefully mapped out and proper population surveillance carried on by people with adequate expertise. Chemical control should be carefully evaluated for efficacy in relation to timing and number of applications. Protection of fruits should be initiated when they are ¼" in diameter and most attractive to the egglaying flies.

SEE ALSO:

Aphids, page 5.
Colorado potato beetle, page 38.
European corn borer, page 26.
Green peach aphid, page 6.

POTATO

COLORADO POTATO BEETLE, *Leptinotarsa decemlineata* (Say)

HOSTS: Potato, tomato, eggplant, tobacco, pepper and other related crops.

DAMAGE: Both the adult and larva devour the host plants foliage, causing extensive damage. The adult may spread organisms of spindle tuber, bacterial wilt and ring rot diseases of potatoes.

DESCRIPTION: The adult, also known as "hard shell", is a stout, oval, strongly convex beetle, 3/8" long and ¼" wide, with black and yellow lengthwise stripes (see illustration). The larva, called "soft shell", is dark red to yellowish red, with rows of conspicuous black dots on the sides. They are ½" long and humpbacked. The eggs are elongated and orange-yellow. Pupae are typical of beetles.

LIFE CYCLE: The adult overwinters in the soil and in other protected sites, emerging in the spring to lay up to 500 eggs in groups of a dozen or more, usually on the undersides of leaves. Hatching occurs in a few days. The larvae may feed for three weeks or more, becoming deep orange before entering the soil to pupate. The adults emerge several days later. The complete life cycle requires

Colorado potato beetle; a, adult; b, larva; c, pupa.

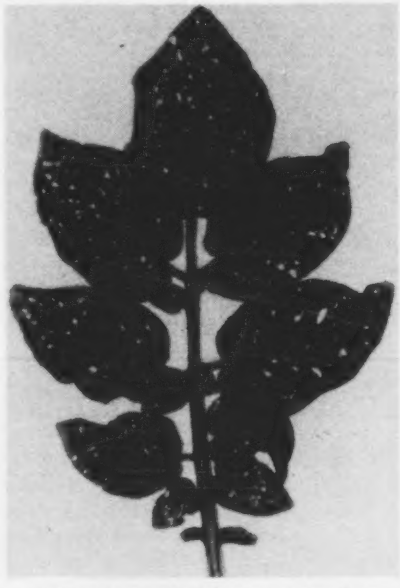
5 to 7 weeks; 2 to 3 generations may occur during the growing season. This is a very prolific insect, prone to severe outbreaks causing extensive damage to host plants.

CONTROL: The control of this pest by means of pest management practices is under study. Chemical control is at present the only means of preventing costly damage to host plants.

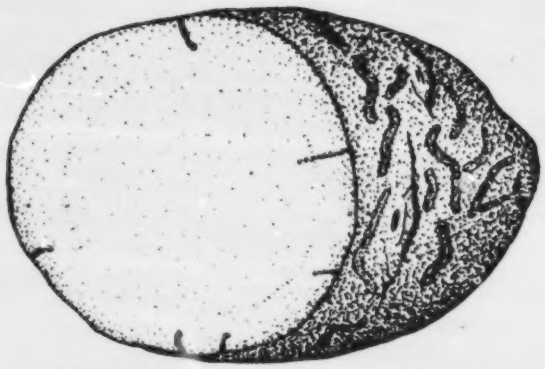
POTATO FLEA BEETLE, *Epitrix cucumeris* (Harris)

HOSTS: Potato, tobacco, eggplant, tomato, pepper and other nightshades as well as a number of other vegetables and weeds.

DAMAGE: The most serious injury is caused to young plants early in the growing season. The adults chew small holes in the leaves, giving them a sieve-like appearance. The larvae feed underground on roots and hypocotyls of seedlings and on potato tubers, causing weakening, wilting and death of seedlings and irregular tunnelling or pitting in the potato tuber. The beetle is instrumental in disseminating and transmitting diseases such as spindle rot, and scab of potato.



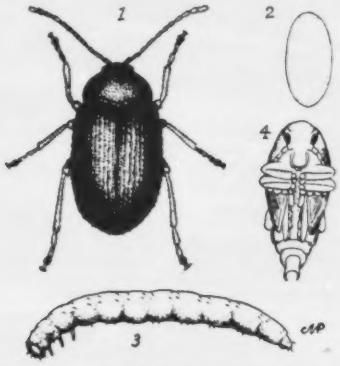
Potato flea beetle injury to potato leaf.



Injury to potato tuber caused by flea beetle larva.

DESCRIPTION: The adult is 1/16" long, uniformly black, with long yellow hind legs which enable it to hop flea-like when disturbed. The whitish yellow larva is 1/5" long and wormlike, with a brown head.

LIFE CYCLE: The adult overwinters in the soil, becoming active in the spring. Minute white eggs, are laid, about 100 per female, in or on the soil near the base of the host plant and hatch about a week later. The larvae feed for two to three weeks and then pupate mostly in earthen cells. There may be one to two generations per year. A generation may be completed in 5 to 6 weeks. Flying adults disseminate the species.



Potato flea beetle: 1, adult; 2, egg; 3, larva; 4, pupa.

CONTROL: After a mild winter, chemical control of this pest may become necessary in spring-early summer, mainly to prevent larval damage to potato tubers. Foliar damage, unless severe, does not cause appreciable crop reduction. Some direct seeded crops may show poor stand due to the tunnelling of larvae into the hypocotyl of seedlings. Close vigilance is required in the latter situation for appropriate control methodology.

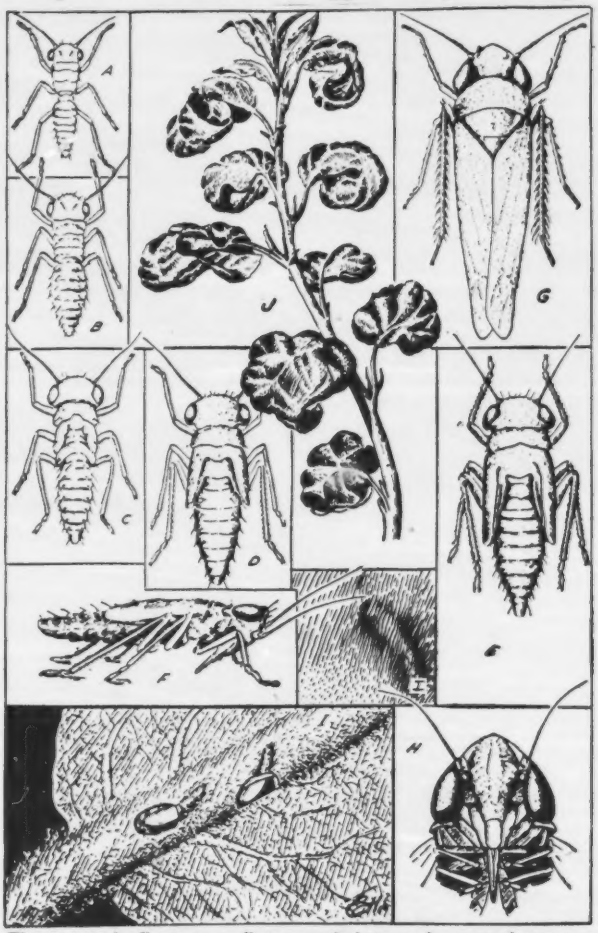
POTATO LEAFHOPPER,
Empoasca fabae (Harris)

HOSTS: Potato, beans, alfalfa, clover, weeds, etc. At times a major pest of potatoes in Massachusetts.

DAMAGE: Feeding of adults and nymphs causes leaf curling, stunting and dwarfing of plants together with yellowing, browning or blighting of the foliage ascribed to the injection of toxic saliva. The condition on potato is known as "hopper burn".

Potato leaf showing "hopper-burn" caused by potato leafhopper.

DESCRIPTION: The wedge-shaped adult is pale green and about 1/8" long, with inconspicuous white spots on the head and back. The very active adult hops when disturbed. The sideways moving nymphs are similar to the adult, but smaller and wingless, and are often mistaken for aphids. The slender white eggs are only 1/20" long.



The potato leafhopper. a, first nymphal stage; b, second stage; c, third stage; d, fourth stage; e, fifth stage; f, side view of fifth stage; g, adult; h, front view of head of adult; i, eggs inserted into leaf tissue; j, curled condition of leaves following leafhopper feeding.

LIFE CYCLE: There is no indication that this leafhopper overwinters in the North and for that reason it is supposed the adults migrate to the Northeast from southern regions. The slightly curved eggs are deposited in slits made by the female in the stems and larger veins of the host plant leaves. They hatch in 6 to 10 days during the summer season. The nymph molts four times before transforming into the winged adult. The cycle from egg to adult may be completed in 3 weeks. There may be 2 to 3 generations per season in Massachusetts.

CONTROL: Strict surveillance should be exercised to detect infestation early in the season and proper control measures applied to prevent serious damage to young crops. Some of the new systemic pesticides applied at planting time may protect the potato crop from the ravages of this pest.

SEE ALSO:

Aphids, page 5
Cabbage looper, page 18.
Corn earworm, page 24.
Cutworms, page 6.
European corn borer, page 26.
Hornworms, page 40.
Stalk borer, page 32.
White grubs, page 13.
Wireworms, page 16.

SPINACH, BEET, CHARD

For pests attacking spinach, beet and chard, see the following:

Aphids, page 5.
Cabbage looper, page 18.
Leaf miners, page 10.
Mites, page 11.
Potato flea beetle and other species, page 38.

TOMATO

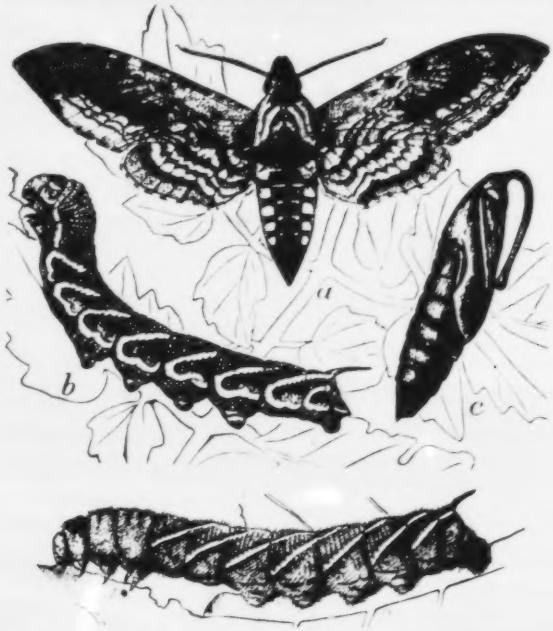
HORNWORMS: Tomato Hornworm, *Manduca quinquemaculata* (Haworth), and Tobacco Hornworm, *Manduca sexta* (Johannson)

HOSTS: Tomato, tobacco, eggplant, pepper, potato and related plants.

DAMAGE: The larvae devour large quantities of the host plant's foliage often leaving only the stem, main veins, and petioles of leaves.

DESCRIPTION: The larvae of both species are green caterpillars up to 4" long. The mature larva of the tomato hornworm has eight V-shaped marks and a prominent black horn at the rear end. The mature larva of the tobacco hornworm has 7 oblique white marks on each side and a red horn at the posterior end. The adults are large fast-flying hawk moths which in flight look like hummingbirds. They have a wing spread of about 5" and can be seen at dusk, hovering over flowers in search of nectar. The eggs are green and spherical. See illustration of pupa.

LIFE CYCLE: Overwintering occurs as pupae in the soil. The adults emerge in the late spring to deposit eggs



Above, the tomato hornworm: a, moth; b, larva; c, pupa. Below, larva of the tobacco hornworm.

which hatch in about 5 days. The eggs are laid on the underside of leaves. Larvae reach maturity in 3 to 4 weeks. Pupation occurs in the soil and may last 2 to 4 weeks. Most of the pupae will overwinter. One to two generations may occur in one year.

CONTROL: Commercial preparations of *Bacillus thuringiensis* are effective against this insect. A tiny wasp may parasitize the worms. The parasitized larvae are usually seen in the field with several white cocoons protruding from the body wall.

SEE ALSO:

Aphids, page 5.
Colorado potato beetle, page 38.
Corn earnworm, page 24.
Fruitflies, page 9.
Green peach aphid, page 6.
Leaf miners, page 10.
Mites, page 11.
Potato flea beetle and other species, page 38.
Whiteflies, page 15.

TOXICITY OF PESTICIDES

Many of the pesticides listed below are not registered for greenhouse use. Letters in parentheses indicate the class of pesticide as follows: (A)-acaracide, (F)-fungicide, (FUM)-fumigant, (H)-herbicide, (I)-insecticide, and (M)-molluscicide.

HIGHLY TOXIC: Acute* oral LD50 (to rats) from 0 - 50+mg/kg. The label of the majority of these pesticides shows the signal words "Danger — Poison" (printed in red) and the skull and crossbones. (From a taste to 7 drops could be lethal to a 150 lb. man.)

COMMON NAME OF CHEMICAL	TRADE NAME	TYPE OF COMPOUND	ACUTE* ORAL(mg/kg)	ACUTE* DERMAL(mg/kg)
Cyanides (Fum)	Cyanogas	calcium cyanide	extremely toxic	extremely toxic
Chloropicrin (Fum)			LC50.8 mg/liter	severe irritation
Methyl bromide (Fum)			LC50-1 mg/liter	extremely toxic
Aldicarb (I)	Temik	carbamate	0.93	2.5
TEPP (I)		phosphate	1.05	2.4
Phorate (I)	Thimet	phosphate	1-3	3.6
Demeton (I)	Systox	phosphate	2-6	8-14
Disulfoton (I)	Di Syston	phosphate	2-7	6-15
Fensulfothion (I)	Dasanit	phosphate	2-11	3-30
Mevinphos (I)	Phosdrin	phosphate	4-6	4-5
Parathion (I)		phosphate	4-13	7-21
Sulfotepp (I)	Dithio	phosphate	5	8
Carbofuran (I)	Furadan	carbamate	5	885
Fonofos (I)	Dyfonate	phosphate	8-17.5	25
EPN (I)	EPN-300	phosphate	8-36	25-230
Carbophenothion (I)	Trithion	phosphate	10-30	27-54
Arsenic compounds (I)			10-50	Toxic
Azinphosmethyl (I)	Guthion	phosphate	11-13	220
Methyl parathion (I)		phosphate	14-24	67
Methomyl (I)	Lannate	carbamate	17-24	1500
Endosulfan (I)	Thiodan	hydrocarbon	18-43	74-130
Methamidophos (I)	Monitor	phosphate	18.9-21	118
Monocrotophos (I)	Azodrin	phosphate	20	342
Phosphamidon (I)	Dimecron	phosphate	20-22.4	107-143
Dioxathion (I)	Delnav	phosphate	23-43	63-235
Mexacarbate (I)	Zectran	carbamate	25-37	1500-2500
Methidathion (I)	Supracide	phosphate	25-48	375
Ethion (I)	Nialate	phosphate	27-65	62-245
Dinitro compounds (F,I,H)	DNOC	dinitro phenol	30	150-600 (guinea pig)
Oxamyl (I,N,A)	Vydate		37	2960 (rabbit)
Dieldrin (I)		hydrocarbon	46-60	60-100
Coumaphos (I)	Co-Ral	phosphate	56	860
Nicotine sulfate (I)		alkaloid	83	285
Phosalone (I)	Zolone	phosphate	96	390
Paraquat (H)			120	480

* Acute poisoning — Severe poisoning which occurs after a single exposure to the pesticide.
Chronic poisoning — Poisoning which occurs as a result of repeated exposures to small doses of the pesticide over a long period of time.

MODERATELY TOXIC: Acute* oral LD50 (to rats) from 50 - 500 mg/kg.
The label of these pesticides shows the signal word "Warning".

Kerosene		solvent	50 for comparison	
Rotenone (I)		botanical	50-75	950+ rabbit
Pentachlorophenol (H,I)	PCP		50-140	mild reaction
Dichlorvos (I)	Vapona	phosphate	56-80	75-107
Oxydemeton-methyl (I)	Meta-Systox-R	phosphate	65-76	250
Bux (I)	Bux-Ten	carbamate	87-170	400 rabbit
Lindane (I)		hydrocarbon	88-125	1000
Arprocarb (I)	Baygon	carbamate	95-100	1000
Crotoxyphos (I)	Ciodrin	phosphate	125	385 rabbit
Pirimicarb (I)	Pirimor	carbamate	147	-----
Chlorpyrifos (I)	Dursban & Lorsban	phosphate	92-267	500-2,000
Chlordimeform (I)	Fundal & Galecron		162-170	255
Aromatic solvents		solvent	170	-----
dimethoate (I)	Cygon	phosphate	215	400-610
Fenthion (I)	Baytex	phosphate	215-245	330
Chlordimeform hydrochloride (I)	Fundal & Galecron		225-280	4000+ ----
Naled (I)	Dibrom	phosphate	250	800
Dichlonfenthion (N,I)	VP-13 Nemacid	phosphate	250-270	6,000
Metaldehyde (M)		hydrocarbon	250-1000	----
Phosmet (I)	Imidan	phosphate	300	3160
Vorlex (Fum)	Vorlex		305	----
Diazinon (I)	Diazinon	phosphate	300-400	455-500
Chlordane (I)		hydrocarbon	335-430	690-840
Diquat (H)			400-440	500+
2,4,5-T (H)			481-500	mild reaction
Fenithrothion (I)	Sumithion	phosphate	500	1300
Plictran (A)			540	2000+
Trichlorfon (I)	Dylox	phosphate	560-630	319

LOW TOXICITY: Acute* oral LD50 above 500 mg/kg. The label of these pesticides shows the signal word "Caution".

Carbaryl (I)	Sevin	carbamate	500-850	4000+
Petroleum solvents		solvent	about 510	----
Crufomate (I)	Ruelene	phosphate	548	3000
Trichlorfon (I)	Dylox-Dipterex	phosphate	560-630	2000+
Ethylene dichloride (Fum)			670-890	3890 rabbit
Formaldehyde	Formalin		800	mild reaction
Metam-Sodium (Fum)	Vapam	carbamate	820	800
Dicofol (A)	Kelthane	hydrocarbon	809-1100	1000
Acephate (I)	Orthene	phosphate	945	----
Chlorobenzilate (A)	Acaraben	hydrocarbon	960-1220	5000+
Malathion (I)	Malathion	phosphate	1,000-1375	4,444
Morestan (A)		carbonate	1100-1800	2000+
Ryania (I)		botanical	1200	4000+ rabbit
Pyrethrum (I)		botanical	1345	2060 rabbit
Ammonium sulfamate (H)	Ammate X		1600-3900	mild reaction
Ronnel (I)	Korlan	phosphate	1940	5000+
Temophos (I)	Abate	phosphate	2000	2000
Kinoprene (I)	Enstar	insect growth regulator	2330	9000 rabbit
Propargite (A)	Omite	sulfite	2500	----
Pentac (A)		hydrocarbon	3160	3160+ rabbit
Trifluralin (H)	Treflan E		3700-10,000	5000
Tetrachlorvinphos (I)	Gardona, Rabon	phosphate	4000-5000	5000+ rabbit
Resmethrin (I)	SBP 1382	synthetic pyrethroid	4240	3040+
Chloropropylate (A)	Acaralate	hydrocarbon	5000	10,200+ rabbit
Methoxychlor (I)	Marlate	hydrocarbon	5000	6000+
Fensulfothion (N,I)	Dasanit	phosphate	7,570	moderate
Perthane (I)		hydrocarbon	8170	----
Tetradifon	Tedion	hydrocarbon	14,700	10,000
Bacillus thuringiensis	Dipel, Biotrol, Thuricide	bacteria	harmless	harmless

FEDERAL INSECTICIDE FUNGICIDE AND RODENTICIDE ACT — CATEGORIES OF TOXICITY

		ROUTE OF ADMINISTRATION			
		LD_{50}			LC_{50}
CATEGORY	SIGNAL WORD ON THE LABEL	ORAL (mg/kg)[1]	Probable Oral Dose for a 150 lb. man	DERMAL (mg/kg)[1] 24 hour exposure	INHALATION (µg/l)[2]
I (HIGHLY TOXIC)	DANGER — skull and crossbones — POISON	0 to 50	a few drops to a teaspoonful	0 to 200	0 to 2,000
II (MODERATELY TOXIC)	WARNING	over 50 to 500	over one teaspoonful to one ounce	over 200 to 2,000	over 2,000 to 20,000
III (SLIGHTLY TOXIC)	CAUTION	over 500 to 5,000	over one ounce to one pint or one pound	over 2,000 to 20,000	
VI (RELATIVELY NONTOXIC)	none*	over 5,000	over one pint or one pound	over 20,000	

NOTE: * None required based on acute toxicity; however, nature of product and use pattern may require appropriate precautionary statements.

LD_{50} — the dose level which will kill 50% of test animals. Minimum of 14 days observation. Animals fasted for oral studies.

LC_{50} — the air concentration which will kill 50% of test animals exposed for a period of 1 hour. Minimum of 14 days observation. Vapor or gas may be expressed in ppm.

[1]Equivalents: 1000 milligrams (mg) = 1 gram (g); 28.3 grams = 1 ounce; 1 kilogram (kg) = 2.2 pounds (lb)

[2]Equivalents: 1 liter (l) = 1.06 quarts; 1000 micrograms (µg) = 1 milligram (mg)

READ THE LABEL

THE METRIC SYSTEM

Within the next 10 years, the use of the metric system of measurement will increase in the United States. Since label instructions will be shown in metric measurements applicators will need to familiarize themselves with this system and its U.S. equivalents.

The metric system is based on the decimal system. The basic units are:

meter = 3.28 ft. = 39.37 in. (a little longer than a yard)
liter = 33.8 fl. oz. (a little larger than a quart)
gram = 0.0353 oz. (about the weight of a paper clip)

Common prefixes used with these basic metric units are:

milli: one-thousandth (0.001)
- 1000 millimeters = 1 meter
- 1000 milliliters = 1 liter
- 1000 milligrams = 1 gram

centi: one-hundreth (0.01)
- 100 centimeters = 1 meter
- 100 centiliters = 1 liter
- 100 centigrams = 1 gram

deci: one tenth (0.1)
- 10 decimeters = 1 meter
- 10 deciliters = 1 liter
- 10 decigrams = 1 gram

deca: ten times (10)
- 1 decameter = 10 meters
- 1 decaliter = 10 liters
- 1 decagram = 10 grams

hecto: one hundred times (100)
- 1 hectometer = 100 meters
- 1 hectoliter = 100 liters
- 1 hectogram = 100 grams

kilo: one thousand times (1000)
- 1 kilometer = 1000 meters
- 1 kiloliter = 1000 liters
- 1 kilogram = 1000 grams

Some useful measures and metric equivalents are:

Linear measures:

one inch = 2.54 centimeters = 25.4 millimeters
one millimeter = 0.0394 in. = about 1/25 in. = 1.000 microns
one centimeter = 10 millimeters = 0.3937 in. = about 2/5 in.
one meter = 100 centimeters = 1000 millimeters = 3.28 ft. = 39.37 in.
one kilometer = 1000 meters = 0.6214 mile

Area measures:

1 sq. centimeter = 100 sq. millimeters = 0.15499 sq. in.
1 sq. decimeter = 100 sq. centimeters = 15.499 sq. in.
1 sq. meter = 1 centiare = 100 sq. decimeters = 1,549.9 sq. in. or 1.196 sq. yards
1 are = 100 sq. meters = 119.6 square yards
1 hectare = 100 ares = 10,000 sq. meters = 2.471 acres
(centiare, are, and hectare are used in land measurements)
1 sq. ft. = 144 sq. in. = 0.0929 sq. meter
1 sq. yd. = 9 sq. ft. = 0.8361 sq. meter
1 acre = 43,560 sq. ft. = 0.4047 hectare

Weight measures:

1,000 milligrams = 1 gram = 0.03527 ounce = 15.432 grains
1,000 grams = 1 kilogram = 2.2046 lbs.
1,000 kilograms = 1 metric ton = 2,204.6 lbs.
1 dram = 17,718 grams
1 ounce = 16 drams = 28.3495 grams
1 pound = 16 ounces = 453.59 grams

Liquid measures:

1 fluid ounce = 29.5729 milliliters
1 pint = 16 fluid ounces = 473.167 milliliters
1 quart = 2 pints = 32 fluid ounces = 946.33 milliliters
1 gallon = 4 quarts = 8 pints = 128 fluid ounces = 3.7853 liters
1 liter = 1000 milliliters = 1.0567 quarts = 33.8 fluid ounces

Volume measures;

1000 cubic millimeters = 1 cubic centimeter = 0.06102 cu. in.
1000 cubic centimeters = 1 cubic decimeter = 61.02 cu. in.
1000 cubic decimeters = 1 cubic meter = 35.14 cu. ft.

17

USEFUL CONVERSION FACTORS FOR COMMON MEASUREMENT UNITS

Type of measurement	Multiply	By	To convert to
Length	inches	25.4	millimeters
	feet	30.48	centimeters
	yards	0.9144	meters
	miles (statute)	1.609	kilometers
	millimeters	0.03937	inches
	centimeters	0.03281	feet
	meters	1.094	yards
	kilometers	0.6214	miles
Area	square inches	6.452	square centimeters
	square feet	0.0929	square meters
	square yards	0.8361	square meters
	square miles	2.59	square kilometers
	acres	0.4047	square hectometers (hectares)
	square centimeters	0.155	square inches
	square meters	10.76	square feet
	square meters	1.196	square yards
	square kilometers	0.3861	square miles
	square hectometers (hectares)	2.471	acres
Mass weight	ounces	28.3495	grams
	pounds	0.4536	kilograms
	short tons	0.9078	megagrams (metric tons)
	grams	0.03527	ounces
	kilograms	2.205	pounds
	megagrams (metric tons)	1.1016	short tons
Liquid volume	ounces	29.57	milliliters (cubic centimeters)
	pints	0.4732	liters
	quarts	0.9463	liters
	gallons	3.785	liters
	milliliters (cubic centimeters)	0.0338	ounces
	liters	2.113	pints
	liters	1.057	quarts
	liters	0.2642	gallons
Temperature	degrees Farenheit (°F)	5/9 after subtracting 32	degrees Celsius (°C)
	degrees Celsius	9/5 then add 32	degrees Farenheit

APPLICATION RATES OF ACTIVE INGREDIENT PER ACRE FOR VARIOUS CONCENTRATIONS OF EMULSIFIABLES, WETTABLES, AND DUSTS

Amount of Actual Chemical Recommended Per Acre

Pounds of active chemical recommended per acre:									
1/8	1/4	1/2	3/4	1	1 1/2	2	2 1/2	3	5
Amount of formulation needed to obtain the above amounts of active chemical for: 10%-12% Emulsion Concentrate (contains 1 pound chemical per gallon)									
1 pt	1 qt	2 qt	3 qt	1 gal	1 1/2 gal	2 gal	2 1/2 gal	3 gal	5 gal
15%-20% Emulsion Concentrate (contains 1 1/4 pounds chemical per gallon)									
1/3 qt	2/3 qt	1 1/3 qt	2 qt	2 2/3 qt	1 gal	1 1/3 gal	1 2/3 gal	2 gal	3 2/5 gal
25% Emulsion Concentrate (contains 2 pounds chemical per gallon)									
1/2 pt	1 pt	1 qt	3 pt	2 qt	3 qt	1 gal	5 qt	1 1/2 gal	2 1/2 gal
40%-50% Emulsion Concentrate (contains 4 pounds chemical per gallon)									
1/4 pt	1/2 pt	1 pt	1 1/2 pt	1 qt	3 pt	2 qt	5 pt	3 qt	5 qt
60%-65% Emulsion Concentrate (contains 6 pounds chemical per gallon)									
1/6 pt	1/3 pt	2/3 pt	1 pt	1 1/3 pt	1 qt	2 2/3 pt	3 1/3 pt	2 qt	3 1/3 qt
70%-75% Emulsion Concentrate (contains 8 pounds chemical per gallon)									
1/8 pt	1/4 pt	1/2 pt	3/4 pt	1 pt	1 1/2 pt	1 qt	2 1/2 pt	3 pt	2 1/2 qt
15% Wettable Powder									
3/4 lb	1 1/2 lb	3 1/3 lb	5 lb	6 2/3 lb	10 lb	13 1/2 lb	16 2/3 lb	20 lb	33 1/3 lb
25% Wettable Powder									
1/2 lb	1 lb	2 lb	3 lb	4 lb	6 lb	8 lb	10 lb	12 lb	20 lb
40% Wettable Powder									
5 oz	10 oz	1 1/4 lb	1 7/8 lb	2 1/2 lb	3 3/4 lb	5 lb	6 1/4 lb	7 1/2 lb	12 1/2 lb
50% Wettable Powder									
1/4 lb	1/2 lb	1 lb	1 1/2 lb	2 lb	3 lb	4 lb	5 lb	6 lb	10 lb
75% Wettable Powder									
1/6 lb	1/3 lb	2/3 lb	1 lb	1 1/3 lb	2 lb	2 2/3 lb	3 1/3 lb	4 lb	6 2/3 lb
80% Wettable Powder									
2 1/2 oz	5 oz	5/8 lb	15/16 lb	1 1/4 lb	1 7/8 lb	2 1/2 lb	3 1/8 lb	3 3/4 lb	6 1/4 lb
1% Dust									
12 1/2 lb	25 lb	50 lb	75 lb	100 lb	150 lb	200 lb	250 lb	300 lb	500 lb
5% Dust									
2 1/2 lb	5 lb	10 lb	15 lb	20 lb	30 lb	40 lb	50 lb	60 lb	100 lb
10% Dust									
1 1/4 lb	2 1/2 lb	5 lb	7 1/2 lb	10 lb	15 lb	20 lb	25 lb	30 lb	50 lb

Example shown: If 1 lb. active ingredient is recommended per acre and a 40%-50% emulsion concentrate is used, then 1 qt. of the formulated material is required per acre.

The tables below can be used when preparing pesticide spray formulations of Wettable Powders (WP) or liquid concentrations of Emulsifiable Concentrates (EC) in volumes of water less than 100 gallons.

Example 1: (Use chart 1.) If the label specifies 3 lbs. of wettable powder in 100 gallons of water, then 3 tablespoons of the same wettable powder will be needed to make a one gallon spray formulation.

Example 2: (Use chart 2.) If the label specifies 3 pts. of liquid concentrate in 100 gallons of water, then 4½ teaspoons of the same preparation will be needed to make a one gallon spray formulation.

CHART 1

Water	Quantity of Wettable Powder Pesticide Needed					
100 gal	1 lb.	2 lbs.	3 lbs.	4 lbs.	5 lbs.	6 lbs.
50 gal.	½ lb.	1 lb.	1½ lb.	2 lbs.	2½ lbs.	3 lbs.
25 gal.	¼ lb.	½ lb.	¾ lb.	1 lb.	1¼ lbs.	1½ lbs.
5 gal.	5 T.	10 T.	15 T. or 1 cup	20 T. or 1¼ cup	25 T. or 1½ cup	30 T. or 1¾ cup
1 gal.	1 T.	2 T.	3 T.	4 T.	5 T.	6 T.

CHART 2

Water	Quantity of Liquid Concentrate Pesticide Needed					
100 gals.	½ pt.	1 pt.	2 pts.	3 pts.	4 pts.	5 pts.
50 gals.	½ C.	½ pt.	1 pt.	1½ pts.	2 pts.	2½ pts.
25 gals.	2 fl. oz.	4 fl. oz.	1 C.	1½ C.	1 pt.	1¼ pts.
5 gals.	1 T.	2 T. or 1 fl. oz.	4 T. or 2 fl. oz.	6 T. or 3 fl. oz.	8 T. or 4 fl. oz.	10 T. or 5 fl. oz
1 gal.	¾ t.	1½ t.	3 t.	4½ t.	6 t. or 2 T.	7½ t.

T. = tablespoon t. = teaspoon C. = cup fl. oz. = fluid ounce

EQUIVALENTS HELPFUL FOR THE MEASUREMENT OF SMALL QUANTITIES OF LIQUID MATERIAL

Gallons	Quarts	Pints	Fluid Ounces	Cups	Tablespoons	Teaspoons	Milliliters (cubic centimeters)
1	4	8	128	16			
	1	2	32	4			
		1	16	2	32		
			1	1/8	2	6	30
				1	16	48	240
					1	3	15
						1	5

3 teaspoons	=	1 tablespoon				
2 tablespoons	=	1 fluid ounce	=	6 teaspoons		
4 tablespoons	=	12 teaspoons	=	¼ cup	=	2 fluid ounces
1 cup	=	16 tablespoons	=	8 fluid ounces		
2 cups	=	32 tablespoons	=	1 pint	=	16 fluid ounces
2 pints	=	64 tablespoons	=	1 quart	=	4 level cups
4 quarts	=	8 pints	=	1 gallon	=	16 level cups

To secure accuracy of measurement of liquid material, the purchase of graduated cylinders of 100 and 500 milliliter (cubic centimeter) capacity is strongly suggested.

PESTS LISTED IN ALPHABETICAL ORDER

Aphids
- cabbage ... 18
- corn leaf ... 26
- green peach ... 6
- lettuce root ... 34
- melon ... 6
- pea ... 37
- potato ... 6

Armyworms
- common ... 22
- fall ... 23

Asparagus beetle ... 16
Asparagus miner ... 17
Beetles
- asparagus ... 16
- Colorado potato ... 38
- corn flea ... 26
- Japanese ... 12
- Mexican bean ... 17
- potato flea ... 38
- sap ... 30
- striped cucumber ... 34

Bean weevil ... 17
Billbug (illustrations only) ... 24
Black or greasy cutworm ... 7
Borers
- European corn ... 26
- stalk ... 32
- squash vine ... 33

Bronzed cutworm ... 7
Cabbage aphid ... 18
Cabbage looper ... 18
Cabbage maggot ... 19
Cabbage worm, imported ... 20
Carrot weevil ... 21
Carrot rust fly ... 21
Colorado potato beetle ... 38
Common armyworm ... 22
Corn blotch leaf miner ... 11
Corn earworm ... 24
Corn flea beetle ... 26
Corn leaf aphid ... 26
Cutworms
- black or greasy ... 7
- bronzed ... 7
- dingy ... 8
- spotted ... 8
- variegated ... 8

Diamond back moth ... 20
Dingy cutworm ... 8
Earwigs ... 9
Earworm, corn ... 24
European corn borer ... 26
Fall armyworm ... 23
Fruit flies ... 9
Garden springtails ... 9
Green peach aphid ... 6
Hornworms (tomato and tobacco) ... 40
Japanese beetle ... 12
Leaf miners (serpentine and blotch) ... 10
Leaf hoppers
- potato ... 39
- six-spotted ... 12

Lettuce root aphid ... 34
Looper, cabbage ... 18
Maggots
- cabbage ... 19
- onion ... 35
- seed corn ... 31
- pepper ... 37

Melon aphid ... 6
Mexican bean beetle ... 17
Mites ... 11
Northern corn rootworm ... 29
Onion maggot ... 35
Onion thrips ... 36
Pea aphid ... 37
Pea weevil ... 37
Pepper maggot ... 37
Potato aphid ... 6
Potato flea beetle ... 38
Potato leafhopper ... 39
Rootworms
- northern corn ... 29
- southern corn (illustration only) ... 30

Sap beetles ... 30
Seed corn maggot ... 31
Six-spotted leafhopper ... 12
Slugs ... 13
Southern corn rootworm (illustration only) ... 30
Spotted cutworm ... 8
Springtails ... 9
Squash bug ... 33
Squash vine borer ... 33
Stalk borer ... 32
Striped cucumber beetle ... 34
Tarnished plant bug ... 13
Thrips, onion ... 36
Variegated cutworm ... 8
Weevils
- bean ... 17
- carrot ... 21
- pea ... 37

Whiteflies ... 15
White grubs ... 13
Wireworms ... 16

Corn Growth Stages in Relation to Borer Attack and Treatment

Adapted by E.H.Wheeler
from USDA, TB 976

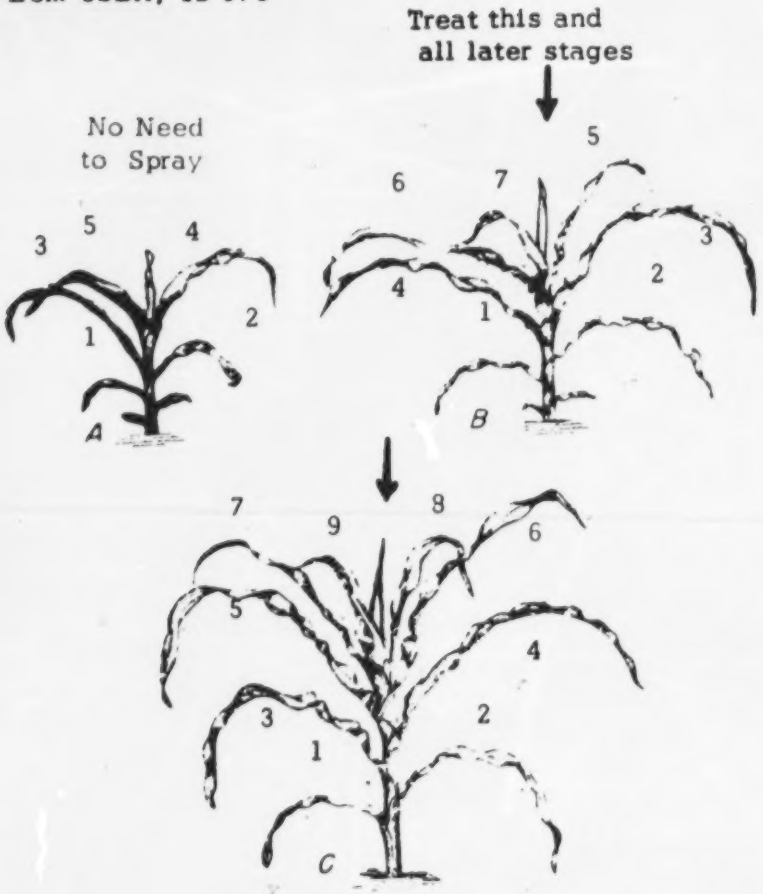


FIGURE 1.—Whorl stages of growth of the corn plant: *A*, Early whorl; *B*, mid-whorl; *C*, late-whorl.

Survival rate of newly hatched borers is very low on plants in early whorl (Fig.1-A) or younger stages. These plants also less attractive to moths for egg laying if larger plants are available.

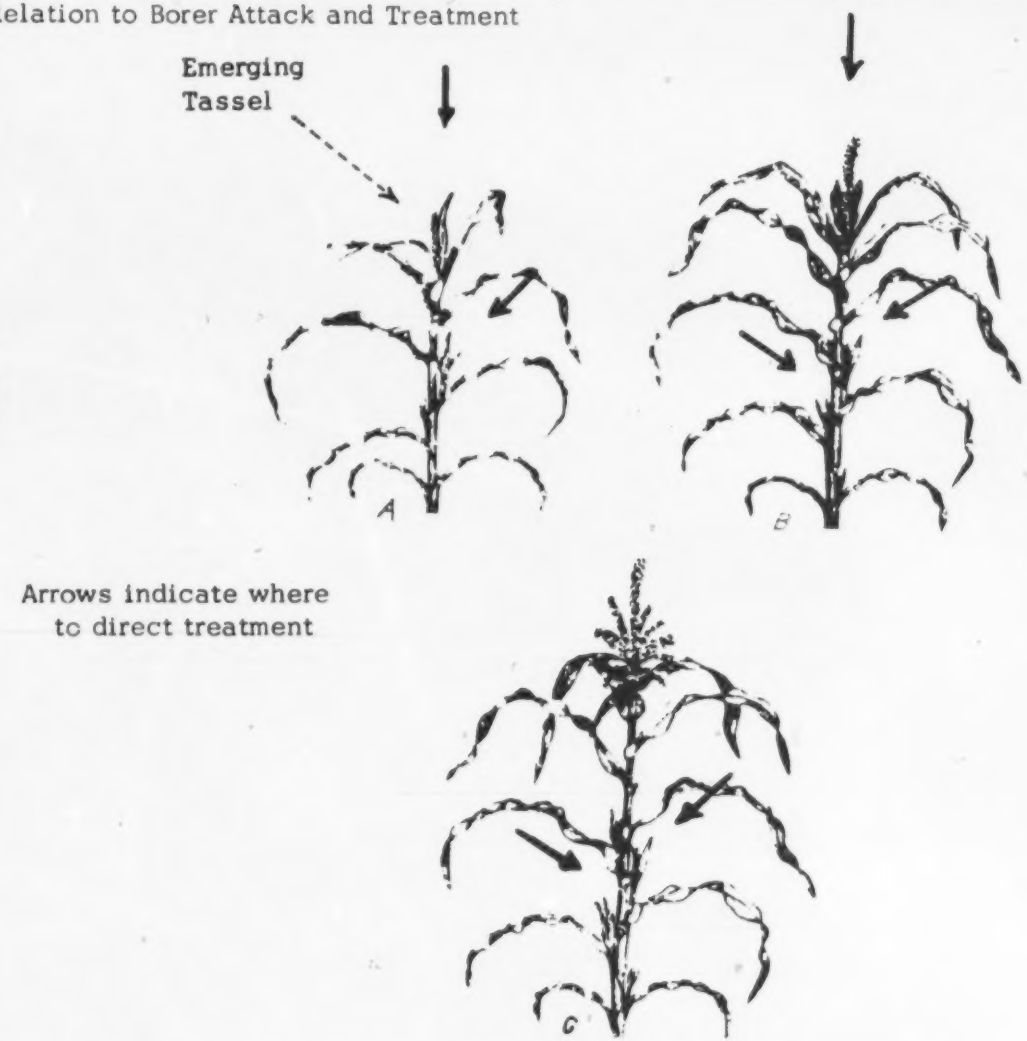


FIGURE 2.—Tassel stages of growth of the corn plant: *A*, Early green-tassel; *B*, mid-green-tassel; *C*, late-green-tassel.

Survival rate is highest during the late whorl and tassel stages (Fig. 1-C, Fig. 2 -A, B, C). All sweet corn in these growth stages is highly susceptible to borers during the 3 to 4 weeks of egg laying and hatching.

All pesticides listed in this publication are registered and cleared for suggested uses according to Federal registrations and State laws and regulations in effect on the date of this publication. When trade names are used for identification, no product endorsement is implied, nor is discrimination intended against similar materials.

NOTICE: THE USER OF THIS INFORMATION ASSUMES ALL RISKS FOR PERSONAL INJURY OR PROPERTY DAMAGE.

WARNING: PESTICIDES ARE POISONOUS. READ AND FOLLOW DIRECTIONS AND SAFETY PRECAUTIONS ON LABELS. HANDLE CAREFULLY AND STORE IN ORIGINAL LABELED CONTAINERS OUT OF REACH OF CHILDREN, PETS, AND LIVESTOCK. DISPOSE OF EMPTY CONTAINERS RIGHT AWAY, IN A SAFE MANNER AND PLACE. DO NOT CONTAMINATE FORAGE, STREAMS, AND PONDS.